the Petroleum Engineer

FOR MANAGEMENT

INTEGRATED EDITION OF THE PETROLEUM ENGINEER

API Fosters Schooling of Personnel

Three Stories of Guatemala

Management Training

Rockwell-Nordstrom Hypreseal valves cut costs on 1500 psi header

THEY GOT A BETTER HEADER

To make sure they got the most dependable flow control (yet with an eye to economy) the production-management team above all agreed on Rockwell-Nordstrom valves. Here's why:

Rockwell-Nordstrom valves are *lubricant sealed* for really positive shut-off. Lubricant also jacks the plug for *instant*, quarter-turn operation even when the valve has been open or closed for months. And since there are no exposed seats to cut away and because lubricant practically eliminates maintenance—they cost less to use and stay in service longer than any other valve.

Rockwell-Nordstrom valves are available at leading oil field suppliers everywhere. You'll pay no more for them, often less, than ordinary valves. No matter where you use them, they give you better performance at lower cost. Rockwell Manufacturing Company, Pittsburgh 8, Pa. *Canadian Valve Licensee:* Peacock Brothers Limited.

ROCKWELL-Nordstrom VALVES

LUBRICANT SEALED FOR POSITIVE SHUT-OFF

40th YEAR *of lubricated plug valve leadership*

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NOVEMBER 1956 One Dollar A Copy

High horsepower needed by new Riverfrac treatment is provided by rugged Allison-powered pumping units.

New fresh water treatment fractures oil and gas wells

RIVERFRAC* is a new Dowell treatment for fracturing oil and gas wells. It uses fresh water, with or without sand, as the frac fluid. After outstanding results in gas wells in the San Juan Basin of New Mexico, Riverfrac is now moving into other areas.

This economical treatment is performed by maintaining relatively high injection rates—usually 30 to 65 barrels per minute.

These rates are easy for the Dowell Allison-powered pumping units. Each unit is capable of delivering 613 hydraulic horsepower. And a companion blender mixes 60 barrels of water and sand per minute. You get high horsepower with a minimum of equipment.

Riverfrac provides other advantages in addition to its availability and low cost. The use of water practically eliminates the fire hazard. And addition agents — such as fluid-loss control and surface-tension reducing agents — are available for use in Riverfrac.

For more information or service, call any of the 165 Dowell offices in the United States and Canada; in Venezuela, contact United Oilwell Service. Or write to Dowell Incorporated, Tulsa 1, Oklahoma, Dept.K-12.

*A Service Mark of Dowell Incorporated

services for the oil industry DOWELL

A SERVICE SUBSIDIARY OF THE DOW CHEMICAL COMPANY

They're stripping gasoline from gas with these "Oilwell" Direct-Connected Compressor Units

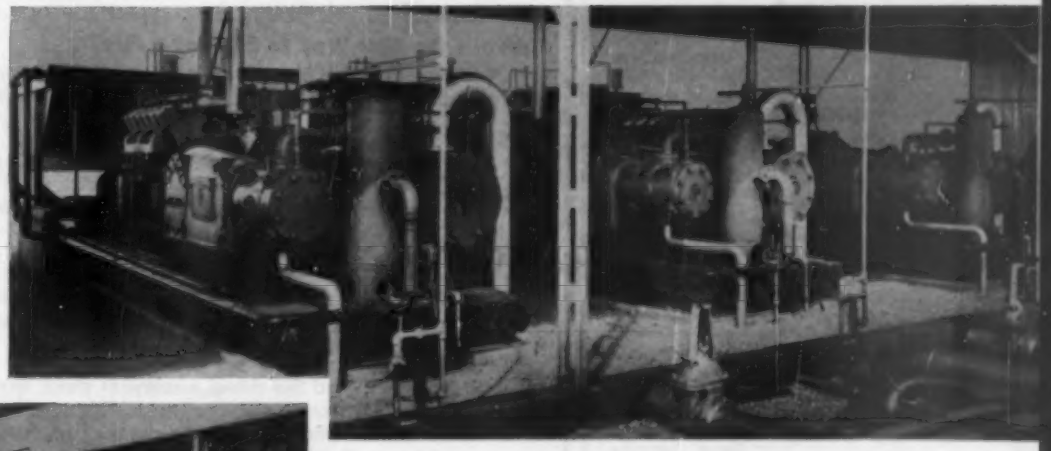
IN this modern gasoline and LPG plant near Norman, Oklahoma, some 3,550,000 cubic feet of gas per day is stripped of condensate and liquid petroleum products.

Three "Oilwell" DGE-250 two-stage compressor units take wet gas from separators at 5 psi and boost it to 445 psi for processing through the plant.

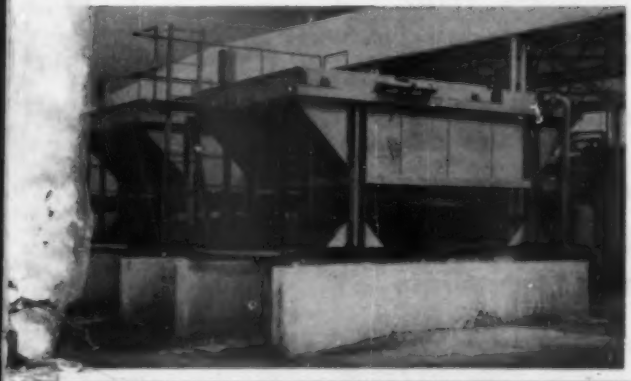
On each unit, the direct drive from prime mover, through right-angle gearing, to two parallel compressors, utilizes the input horsepower with maximum efficiency. V-belts and clutches are eliminated by this arrangement.

Units of this type are available in 125, 175, 200, 250 and 300-hp sizes. On all but the two larger sizes, up-draft radiators are mounted above the compressor gear box and supported directly from the skid base.

This bank of three direct-connected units are tied into a common header system, permitting flexibility of operation.



Heavy-duty, horizontal, up-draft radiators have divided cores for separately cooling engine and compressor. Circulating pumps and cooling fans are driven from the engine crankshaft by means of a torque tube and fluid coupling.



FOR COMPLETE INFORMATION . . . and any assistance desired in analyzing your requirements, contact your nearest "Oilwell" Representative. Field engineers are always available. No obligation.

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A Magazine of Petroleum Management

the Petroleum Engineer

FOR MANAGEMENT

NUMBER 12 • VOLUME XXVIII • NOVEMBER, 1956

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The Petroleum Engineer Publishing Company
Indexed by Industrial Arts Index and The Engineering Index, Inc.
Member of Audit Bureau of Circulation and Associated Business Papers

The Petroleum Engineer for Management, published monthly, August through June, semi-monthly in July, by The Petroleum Engineer Publishing Company, 800 Davis Building, Dallas 2, Texas. Subscription rate to the Petroleum Industry, United States, Canada, and Foreign, $6.00 per year; $10.00 for 2 years; $13.00 for 3 years; $1.00 for single copy. Entered as second-class mail matter May 1, 1932, at the post office in Dallas, Texas, under the act of March 3, 1879.

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Four Editions
Published Monthly by
The Petroleum Engineer
Publishing Company
800 Davis Building
Dallas 2, Texas

Chains Now Fall on Management

Have you read a labor union publication recently? Have you any idea what labor demands for themselves in the next few years? Politicians are adding their expectations of what must be done for the so-called "little" man, whomever that means.

And who is expected to supply these gains marked so conspicuously on the schedule?

YOU.

As petroleum industry management and technology personnel, you are the executors of the will of union leaders and political office holders. You are expected to double wages for petroleum workers in the next five years, provide four to six weeks vacations, virtually free medical and hospital care, and guarantee college education for children of employees.

In order to do that without cutting the value of the dollar in half, management must raise efficiency of operation faster than it has ever been increased before. To pay for only a few political promises now in the air, there is little hope of less taxes and strong indication of more, so savings must also be made to pay for a huge tax load.

Management seldom speaks out for itself despite the growing responsibility piled upon its shoulders. Henderson Supplee, Jr., president of The Atlantic Refining Company, tread comparatively fresh ground when he called recently for economic education of employees so they would understand that increases in wages and benefits must follow advancements in efficiency or be paid in inflated dollars, which are not real gains.

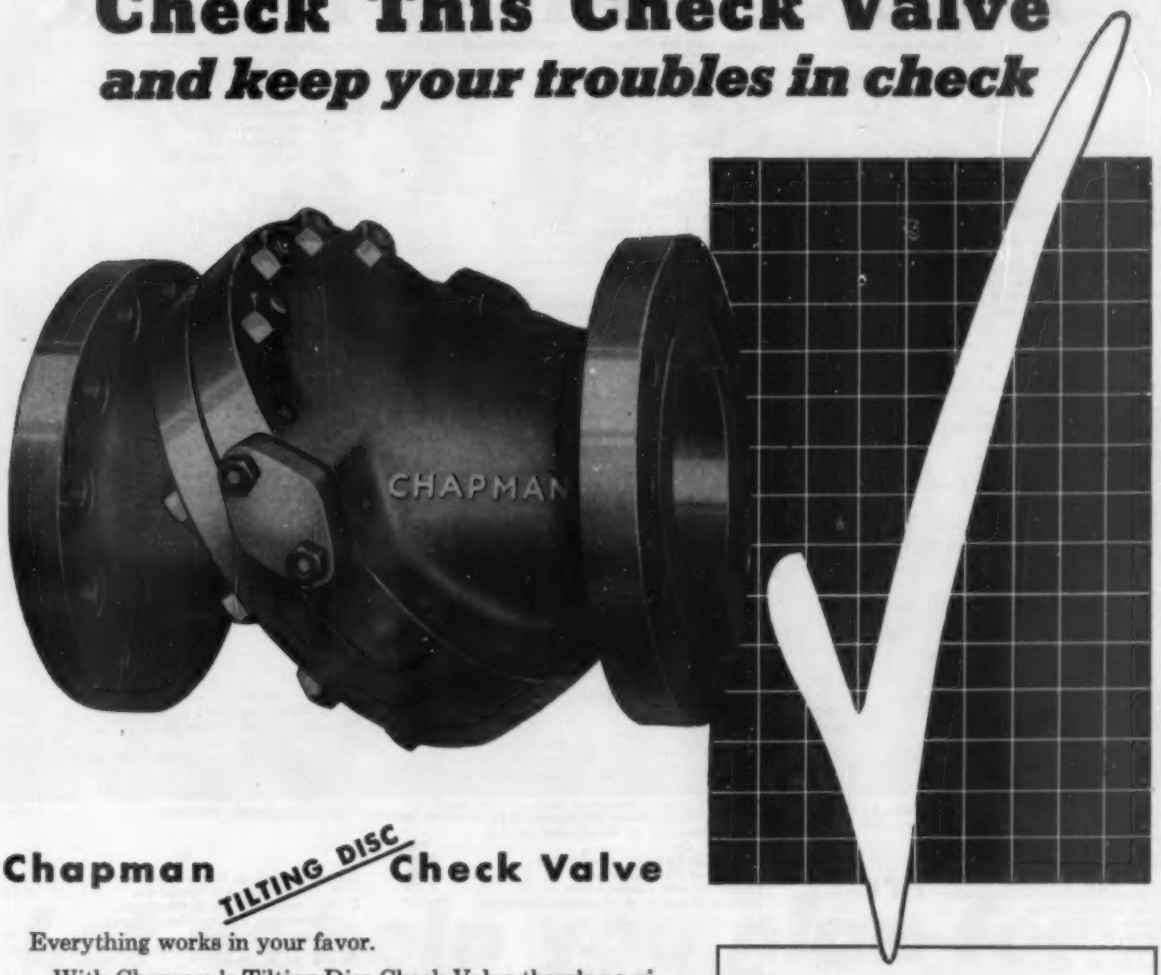
Labor union leaders and labor union publications have a refreshing forthrightness and singleness of purpose that management might adopt to its advantage. Management cannot, of course, display the total bias of labor statements and labor "news" without endangering its reputation for sound, objective principles.

But economic education is vital if private management is not to be replaced by government management. Good managerial personnel is very scarce today. Its pay is proportionately much less in capitalistic countries than in socialist Russia. Only very recently has the health of executives been studied in the United States after decades of management's concern with the health of other employees. Like the teaching profession, management has slipped behind in material gains which is a basic reason for present critical shortages. Prestige is not enough.

Before the end of the 20th century we may hear a new twist to Karl Marx's slogan of a century ago, "Managers and Technicians, arise, you have nothing to lose but your chains."

Ernestine Adams

Check This Check Valve
and keep your troubles in check



Chapman TILTING DISC Check Valve

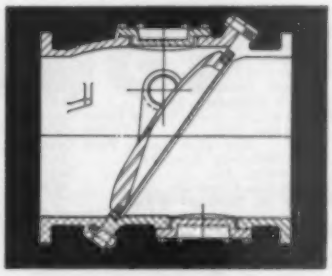
Everything works in your favor.

With Chapman's Tilting Disc Check Valve there's no vibration, no fluttering, no noise. There's no slamming, with usual piping arrangements, no banging to cause damage to system or valve. There's no grinding, scraping or wearing to either the disc or seat.

All of this means less headaches to you . . . both physical and financial headaches. The smooth, sure, quiet action means less, much less, maintenance over the longest period under toughest operating conditions.

Chapman Tilting Disc Check Valves with money-saving advantages like these are available in iron and steel, with standard end to end, for handling fluids or gases under a wide range of pressures. They're listed and shown in our Catalog 30-A. Send for it and check the valves you need for replacement or new piping systems, right now.

The CHAPMAN Valve Mfg. Co.
INDIAN ORCHARD, MASSACHUSETTS



The Valve That Goes with the Flow

Here's the idea in back of it all. When the flow is on, "airfoil" disc is held firmly against stops in the body. When the flow drops, disc balances itself quietly on whatever flow there is. When the flow stops, disc drops quickly and tightly on special bevel seat. It's as sound as that. It's as simple as that. And valve men will be pleased when they see that enough room is given around disc to cut down flow resistance.

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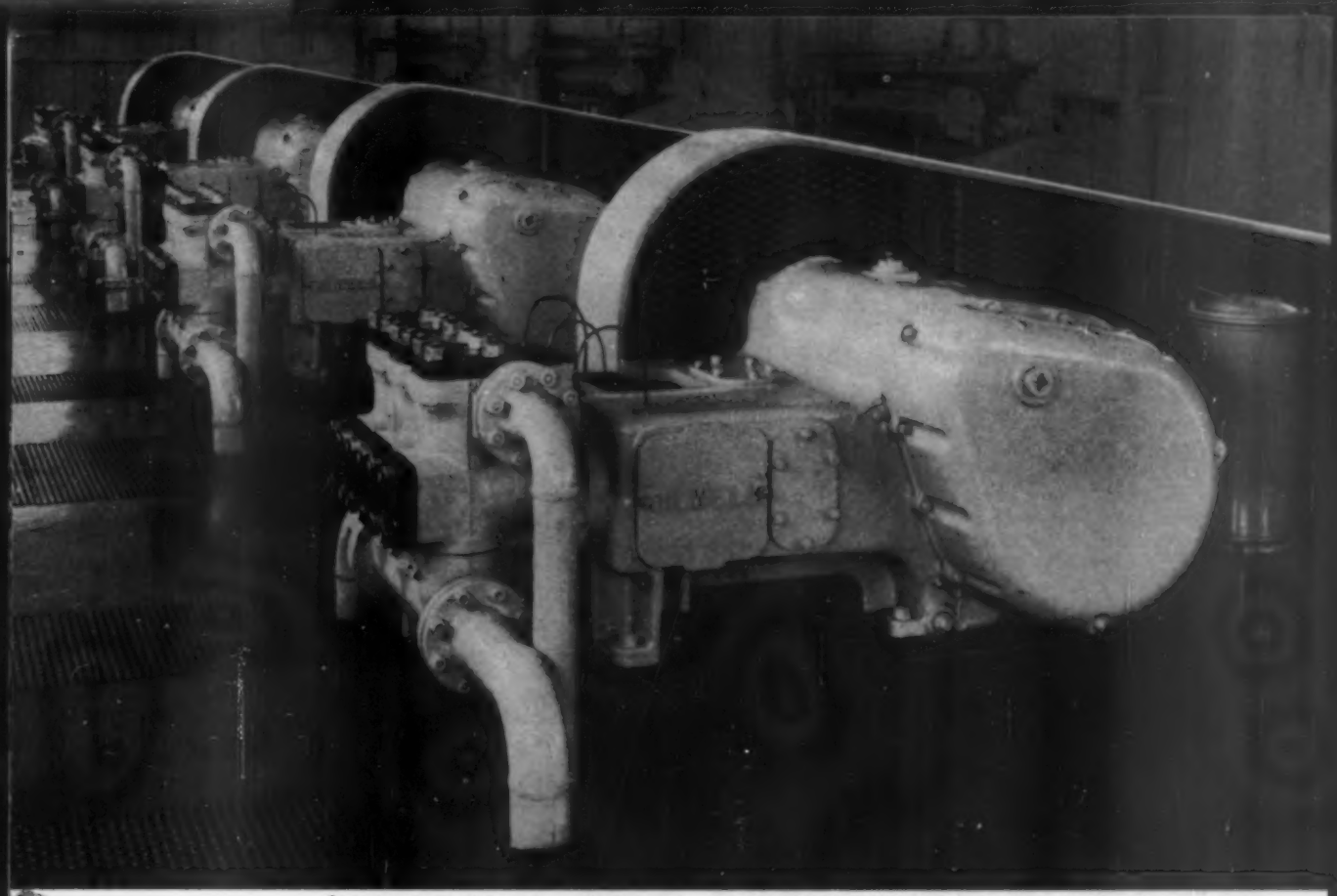

HUNDREDS *of "Oilwell" waterflood pumps have pumped* **HUNDREDS OF MILLIONS** *of gallons with only routine maintenance.*

Let us help you plan for WATERFLOODING!

THERE'S nothing particularly new about waterflooding. "Oilwell," for example, has been building pumps for the purpose since 1927. Nevertheless, more and more new waterflooding practices are being uncovered every day, and it's good business to keep informed on the situation.

You'll find a real storehouse of practical experience tucked under the hat of your "Oilwell" representative. He gets around and understands the basic problems encountered in current waterflooding practices. Needless to say, he's more than willing to discuss them with you.

And, naturally, he's in the very best position to talk about the outstanding line of "Oilwell" Plunger Pumps—available in a great range of displacements, working pressures, gear ratios, and fluid-end materials. He can also help you select automatic controls, metering equipment, prime movers and manifolding materials.

Of course, you'll want specialized engineering assistance in installing any waterflood project. But during the planning stages it's good common sense for you to capitalize on our wide experience and take advantage of our time-proven services.

OIL WELL SUPPLY

DIVISION UNITED STATES STEEL CORPORATION

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UNITED STATES STEEL

Petroleum Profile

WHEN Ralph T. McElvenny was elected chief executive officer of American Natural Gas Company in April, 1954, he took over the responsibility for guiding the company and its subsidiaries which had been the domain of the late William G. Woolfolk since 1932.

Mr. McElvenny had been prepared for this task by education, experience, temperament, and physical tenacity. How successfully he has carried out this responsibility is now a matter of record..

Today the American Natural System is in a period of great expansion. It is not only meeting all the needs of its markets, but is already in the process of additional expansion to provide future requirements.

Mr. McElvenny is a composite of financier, lawyer, tireless utility executive, and outstanding athlete.

These attributes seem to come naturally to the soft-spoken executive, who graduated from Stanford University in 1930 with the degree of Juris Doctor, highest scholastic honor in legal jurisprudence.

His early financial training started with the Guaranty Trust Company in New York. In 1933-34 he served as national bank conservator with the Treasury Department, supervising the affairs of various banks which had been closed during the Bank Holiday. He moved on to the Securities and Exchange Commission as an attorney and administrative officer in the public utilities division.

Mr. McElvenny entered the utility business in 1945 with the old United Light and Power Company, which later broke up its holdings and emerged as the American Light and Traction Company which became American Natural Gas Company in 1949. Mr. McElvenny learned more about the utility business from Chairman Woolfolk, under whom he served as financial vice president and assistant.

He was elected executive vice president of American Natural in May, 1952, and became president in September, 1953. He was chosen executive head of the company following the death of Mr. Woolfolk. Mr. McElvenny is also chairman of the board of Michigan Consolidated Gas Company, Milwaukee Gas Light Company, and Milwaukee Solvay Coke Company. He is chairman of Michigan Wisconsin Pipe Line Company and American Louisiana Pipe Line Company. All are subsidiaries of American Natural. Mr. McElvenny also has served on the board of directors of a number of other utility companies and is presently a member of the board of the National Bank of Detroit, United Foundation, Detroit Symphony and board of trustees of Kalamazoo College.

RALPH T. McELVENNY

President

American Natural Gas Company

Although a prodigious worker at his desk, at the conference table, and on the long distance telephones, Mr. McElvenny has not neglected the recreational side of his life.

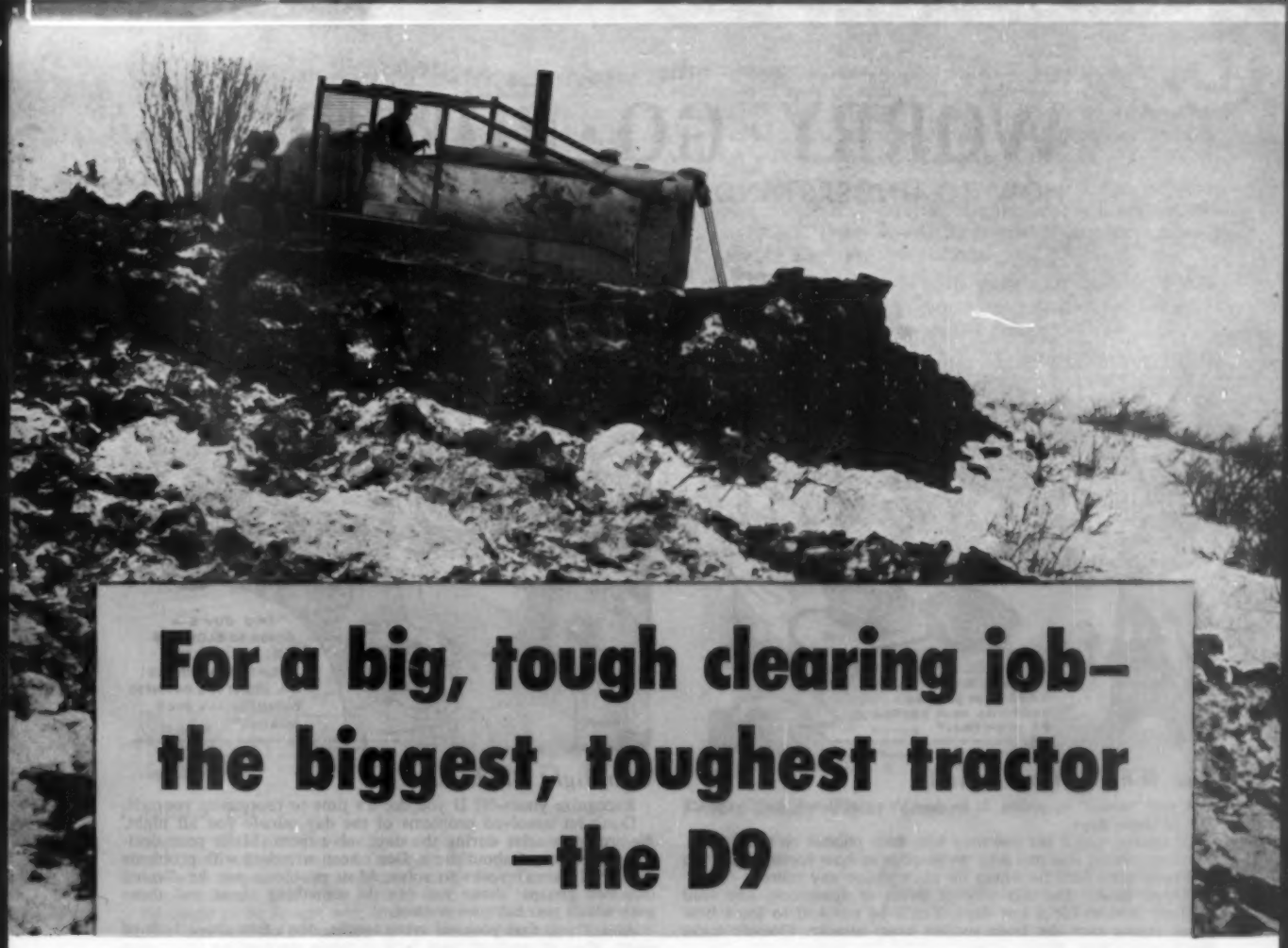
Appearing even younger than his 50 years, he is a tough competitor on the tennis courts, where he was national inter-collegiate doubles champion at Stanford in 1928. He was National Public Parks doubles champion in 1936 and played first doubles for the United States against Canada in the annual Golden Cup competition for senior teams in 1953. He also enjoys hunting, fishing, and golf.

Mr. McElvenny's sense of fair play on the tennis courts extends to his business. It is his firm philosophy that a holding company must be of benefit to the public as well as the stockholders to justify its existence.

He proved this through the construction of the American Louisiana Pipe Line, which has meant more gas at low rates to the millions of people in Michigan and Wisconsin, at a total expenditure of $250,000,000. A small company could never have accomplished such a task, especially when one considers the years spent in preparation, hearings, and litigation before the pipe line became a reality.

Mr. McElvenny has found many other rewards in life. He married the attractive Elisabeth Steiwer, daughter of U. S. Senator Frederick Steiwer of Oregon. Their daughter Alice, 21, is a senior at Vassar, and daughter Elisabeth, 18, has followed her father's footsteps to Stanford. Ralph, Jr., 14, is a student at Detroit University. The McElvenny family lives in Grosse Pointe Farms, Michigan.

UNITED STATES STEEL



For a big, tough clearing job– the biggest, toughest tractor –the D9

This CAT* D9 Tractor is clearing a 50-foot right-of-way through the rugged Blue Mountains of Oregon for Pacific Northwest's 22-inch natural gas line.

To pioneer in the frozen rock, clay and snow, Fulghum Contracting Corp., LaGrande, Ore., used the biggest of the big yellow machines. It has done everything asked of it. Reports Jerry Muldowney of Fulghum, which has 45 other Caterpillar-built units on the job:

"It's doing a very impressive job, particularly on the many side cuts and steep grades. We work it in second gear in rock and third everywhere else."

And here's important news about the D9 for pipeliners. Now you'll get even more production from this giant. *Its Turbocharged engine output has been increased to 320 HP at the flywheel!*

Here's one way to figure the production you get from a D9 equipped with a big No. 9A Bulldozer. On a 50-foot haul, this unit can handle 610 loose cubic yards per hour. This figure can be increased as much as 75% in downhill 'dozing and trenching!

This is a unit that can produce no matter where the pipe takes you. It is equipped with oil clutch or torque converter drive. Steering clutches and air-cooled steering brakes are power boosted. It has a heavy-duty 7-roller track frame and long-lived specially hardened track shoes. It's built for high production no matter what the climate or terrain.

Have your nearby Caterpillar Dealer show you the new D9 soon. He'll demonstrate its work capacity right on your job. Call him today.

Caterpillar Tractor Co., Peoria, Illinois, U.S.A.

CATERPILLAR*

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NAME THE DATE... YOUR DEALER WILL DEMONSTRATE

the

WORRY · GO · ROUND

HOW TO UNDERSTAND YOUR EVERYDAY TENSIONS

Henry B. Rollins, M.D.,
Vice President and Medical Director
The Connecticut Mutual Life Insurance Company

The Wheels Go 'Round

A real "wheel" in action. If he doesn't calm down, he'll explode one of these days.

Of course, you'll see few men with four phones on their desks. We exaggerated this one a bit to emphasize how foolish this man is. Pretty soon he'll be where he can't phone any more.

If you doubt that this way of living is disastrous, just read obituary notices for a few days. You'll be shocked to learn how many young men die from sudden heart attacks. Doesn't make much sense, does it?

If you'll read on, perhaps you'll see yourself in some of these pictures.

CONTRACTS
HI TENSION
" THIS GUY'S A CINCH TO BLOW HIS LID: ALL DAY IT'S BUSINESS BUSINESS; ALL NIGHT IT'S BUSINESS BUSINESS ALL OVER AGAIN."
RAMA

Moonlight Madness

Recognize yourself? If you do, it's time to reorganize yourself.

Don't let unsolved problems of the day pursue you all night. As problems arise during the day, solve them. Make your decisions, then forget about them. Don't keep wrestling with problems that really aren't yours to solve. Most problems can be divided into two groups: those you can do something about and those over which you have no control.

And if you find yourself lying awake, don't fret about lack of sleep. Most of us don't need half as much sleep as we think. But we do need rest. So if you can't sleep, take it easy. You'll feel much better in the morning.

Wishful Dreamer

Perhaps you think this dreary, passive-looking guy wouldn't develop high tension. But you're wrong. It just doesn't show on the surface.

Frustration is one of HiTension's strongest allies. While his work piles up, this apathetic individual dreams about getting a more important job. He neglects his work, becomes bored with life and dreams about the big role he *should* be playing.

Our day-dreamer doesn't realize that many top executives in his own company once had jobs no more glamorous than his. He has never learned the satisfaction of doing his own job well.

Jittery Joe

Do you know how Winston Churchill cured himself of speech-fright? Yes, he used to have it, just like most of us.

The story goes that Sir Winston suffered agonies before campaign speeches. But he gained confidence by reminding himself that he knew more than his audience about his subject.

Doctors agree that continued nervous tension can cause a variety of illnesses. If you're worried about making a speech, just remember that you're in good company. Arm yourself with plenty of information about your subject. Then HiTension won't have a chance to get started.

Many years ago Plato said,

"So neither ought you attempt to cure the body without the soul; and this is the reason why the cure of many diseases is unknown to the physicians of Hellas, because they are ignorant of the whole, which ought to be studied also. For this is the great error of our day in the treatment of the human body, that physicians separate the soul from the body."

Today we know that emotional troubles cause many illnesses. Continued anxiety and tension are slow poisons.

This booklet offers no easy cure-all, makes no attempt to prescribe any treatment. Our cartoons dramatize the more common causes of emotional disturbances, particularly as they affect businessmen and their families. All we hope to do is to help you understand yourself a little better, to help you see what uncontrolled emotions can do.

Understanding is the beginning of self-knowledge. And the better we understand ourselves, the better we will understand our neighbors. Then we can be free with one another and better enjoy our daily associations.

If this booklet helps you understand your tensions, it will serve its purpose. Happy people are effective people. And happy, effective people are healthy people.

Envious Ed

Look at Ed! How can he do his job if he lets envy strangle him? Think of the nervous energy this man uses worrying about what someone else is getting paid. Envy never increased anyone's salary.

Ed ought to be honest with himself, try to face up to his own frustrations and do something about them. For only frustrated people are envious of others. Let Ed look to himself.

Put all you've got into your work. You'll get a kick out of working at the top of your ability. Your life is for yourself; make the best of it. You'll have something no one can take away from you.

"MOTHER FEELS NEGLECTED; DAUGHTER FEELS PUT UPON; SON FEELS MISUNDERSTOOD; FATHER IS FED UP — THEY CAN'T EVEN EAT DINNER. HAVE I GOT THIS FAMILY SEWN UP!"
HI TENSION

The Family Next Door

Look at this family. They don't understand one another. They grumble, complain and criticize. They have a miserable time. Homes like this are breeding grounds for emotional illnesses.

Don't take your troubles, your little peeves to the table. Try to understand each other's needs, as well as your own. Try to help one another.

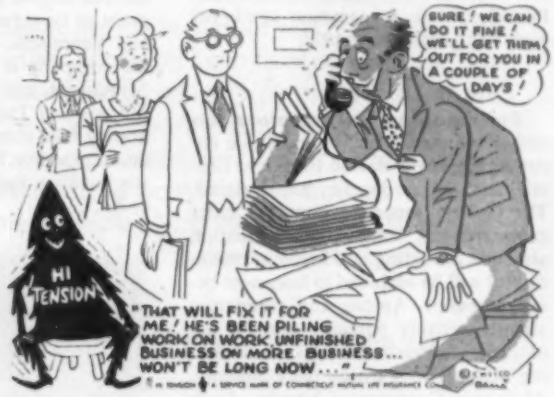
The surest, easiest and most pleasant way to avoid indigestion is to relax while you eat. Have fun together. Laugh. Keep HiTension away from your table. Enjoy what you eat and eat what you enjoy.

CONGRATULATIONS, BILL! YOU'RE OUR NEW VICE-PRESIDENT. PLENTY OF RESPONSIBILITY BUT YOU CAN HANDLE IT...
"HE'S AFRAID OF RESPONSIBILITY. AFRAID OF SUCCESS... I'LL HAVE HIM JUMPING OUT OF HIS SKIN AFTER A WEEK ON THE JOB.
HI TENSION

Have I Got What It Takes?

Every businessman will recognize this fellow. All his working life he has fought to get to the top. Now his big moment has come. Suddenly panic grips him.

HiTension is beginning to bore in, create anxieties and undermine his self-confidence. If our friend doesn't understand, it's only natural to have a few momentary qualms, he's in for trouble. A mature man knows he can master his fears by facing them. When opportunities come, he accepts them gladly. If this man hadn't shown plenty of ability during his career, he wouldn't have been chosen for an important job. So what's he worrying about?


SURE! WE CAN DO IT FINE! WE'LL GET THEM OUT FOR YOU IN A COUPLE OF DAYS!
HI TENSION
"THAT WILL FIX IT FOR ME! HE'S BEEN PILING WORK ON WORK UNFINISHED BUSINESS ON MORE BUSINESS... WON'T BE LONG NOW..."

Yes Man!

Good old Joe! He can't say "no." There's one in every office. Everybody takes advantage of him. Then suddenly Joe has a heart attack. He's away from the office for three or four months. Yet the business goes on.

If there is a Joe in your office, show him this example of how HiTension can slowly build up such pressure that something has to give. If it hurts Joe's feelings to realize that no one is indispensable, he'll get over it. But he may never get over the damage he inflicts on himself by taking on more than he can handle.

Joe must learn to say "no." He can't take on everything.

HIGHLIGHTS ★ ★ ★

Digest of News and Comment

Seven out of 100 employees in the U. S. oil industry are either scientists or engineers, the National Petroleum Council has reported in a recent survey for the Office of Oil & Gas, Department of Interior. NPC also estimated that the oil and gas industry now gainfully employs 863,000 persons, excluding all persons employed in retail outlets and retail services. Breakdown of the report showed that 313,500 persons were employed in the division of crude oil and natural gas exploration and development, 209,400 employed in petroleum and products refining, 113,000 engaged in the transportation, including 33,000 employed in gas transmission, and 277,900 persons in the distributing division. Technical personnel numbered 33,091 — 11,887 scientists and 21,204 engineers.

★ ★ ★

American Petrofina, Inc., trading on the American Stock Exchange began October 1. American Petrofina is the surviving company of a recent merger involving Panhandle Oil Corporation. American Petrofina is an affiliate of Compagnie Financiere Belges des Petroles (Petrofina of Belgium), an international organization engaged in production, refining, marketing, and transportation of oil. Panhandle stockholders voted approval of the plan, and are to receive 1.3 shares of American Petrofina class A common stock for each Panhandle share held.

★ ★ ★

Panamanian oil exploration and development will definitely be encouraged, newly-elected President Ernesto de La Guardia, Jr., has declared. The Central American country's chief executive has stated that legislation aimed at attracting and helping foreign capital will be included in laws now being prepared. Among the companies already actively pursuing mineral exploration in Panama are Cataract Mining Corporation, Union Oil Company, Aluminum Company of America, Utah Construction Company, and the Honduras Rosario Mining Company.

★ ★ ★

"Don't skim the cream off Texas oil fields" at current prices to meet emergency demands growing out of the Suez problem, warns French M. Robertson, president of Texas Mid-Continent Oil & Gas Association. The Abilene, Texas, independent producer declared that "if our flush production is produced in an emergency — which I am confident will not last forever — then we will be left with even more costly oil and our competitive position will be even worse when other foreign oil comes onto the market. A price increase would assure the most efficient use of these natural resources."

★ ★ ★

Science-for-Youth program of D-X Sunray Oil Company has been featured in a nationwide telecast sponsored by the National Association of Manufacturers. The program, in which children of company employees receive free instruction at the company's research labs, gained national acclaim this past spring when the first session was completed, "graduating" 40 youngsters. The students, ranging from seventh to twelfth grades, turned out twice a month to work on scientific projects of their choice under instruction of company scientists.

★ ★ ★

Venezuelan oil operations of Venezuela Syndicate have been greatly increased by the recent acquisition of assets of Talon Petroleum, C. A. Cecil V. Hagen, president of Venezuela Syndicate, indicated that the purchase was the first step in a major expansion program to be extended in both the U. S. and Venezuela. Controlling interest of the company is held by Hagen, Clint Murchison, and Roy B. Kelly. Among the assets of Talon acquired are an operating field camp, producing oil wells, and a pipe line from the wells to deep-sea loading facilities in Lake Maracaibo.

Restraint of trade charges against Warren Petroleum Company have been dismissed by the Federal Trade Commission. Also involved were Warren's affiliates, Butane Wholesale Company, Little Rock, Arkansas, and Zero LP-Gas Company, Lake Village, Arkansas. Commission found that there was not enough evidence to sustain charges that the firms had lowered retail prices in 1952 and 1953 to suppress competition, as alleged.

★ ★ ★

Government of Pakistan and Pakistan Petroleum, Ltd., have completed negotiations for a 50-50 profit sharing agreement. Other provisions provide for "consideration" being given construction of an oil refinery, and also for the training and employment of Pakistani nationals in oil industry work. Several other companies are already active in oil exploration with Pakistan boundaries.

★ ★ ★

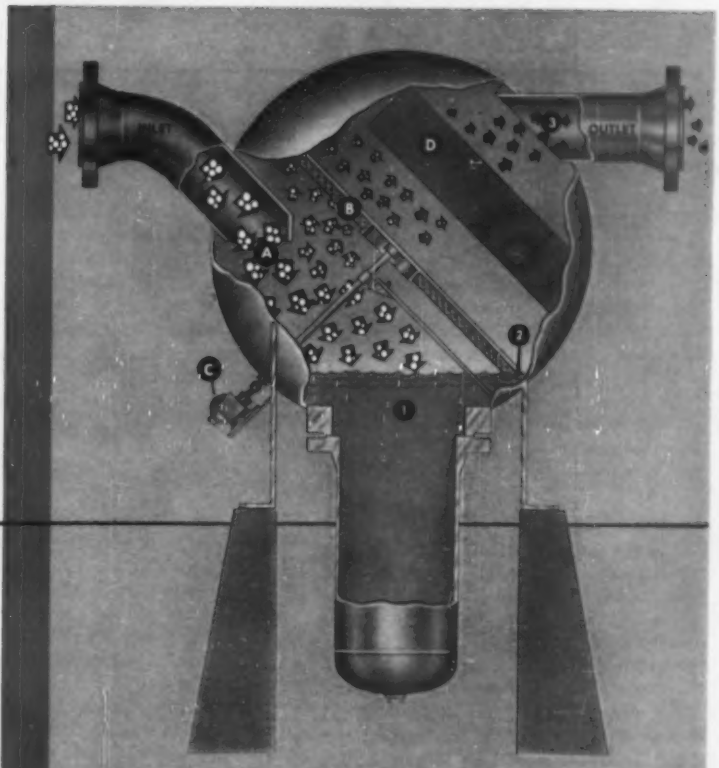
Humble Oil & Gas Company's discovery of sulfur six miles out into the Gulf of Mexico off the coast of Louisiana continues to bring trouble. Humble found the sulfur on a lease in the state-government disputed area. Interior Department says that a company may develop oil or sulfur — but not both; Louisiana-sold leases allow development of several minerals. With this in mind, Humble has attempted to turn the find to Freeport Sulphur Company for development. Senator O'Mahoney of Wyoming has indicated that anti-trust proceedings might be filed, since Freeport produces about one-third of the U. S. sulfur market. Freeport and Humble had planned to share profits from the operation.

"Destination Earth" has joined the ranks of API's many successful educational filmstrips during Oil Progress Week in October. Fun, fantasy, and a common-sense demonstration of the American way of life are the chief ingredients of the 13-minute satire in Technicolor. Hero of the film is Colonel Cosmic, who finds that America's secret of success and abundance is based on competition and oil.

MORE EFFICIENT RESULTS!

PEERLESS SCRUBOSPHERE*

*Spherical scrubber for dust and liquid removal from gas flow

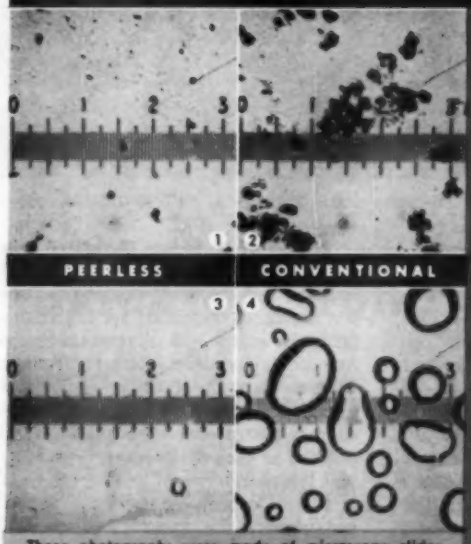


(A) The majority of incoming liquid and solid particles are directed down into reservoir. 1

(B) Lighter solid particles carried by gas stream are separated on surfaces of contactor which are kept wet and clean by revolving through liquid reservoir. 2

(C) Contactor is revolved by explosion-proof gear motor.

(D) Mist Extractor removes any remaining liquid particles from gas stream prior to outlet. 3



These photographs were made of microscope slides introduced downstream of the Scrubosphere and a conventional vertical oil bath cleaner under the same operating conditions. Plates 1 and 2 show the comparative amounts of iron oxide not removed with the amounts introduced being identical. Plates 3 and 4 indicate comperative oil loss with vapor rate through the vessels being the same.

LOOK AT THIS TEST The test at the left indicates the superiority of Peerless Scrubosphere over conventional oil bath dust scrubbers. The SCRUBOSPHERE operates with no loss of efficiency at low flows, minimum liquid loss, and very low pressure drop. Other outstanding features include easy vessel access with removable self-cleaning contactor, a sump for slugs of solid or liquid particles, and minimum cost.

For detailed information write for Bulletin No. 180

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PEERLESS MFG. CO. DALLAS TEXAS

To support and encourage cultural, educational, and scientific activities in Venezuela, the Creole Petroleum Corporation is establishing a new foundation, established as a separate legal corporation with its own staff and board of directors. It is expected that it will be in operation before the end of the year. Creole is providing it with a substantial operating budget during its first year of operation, as well as provide financially for its future activities on a long-term basis. Announcements of certain initial grants under the new foundation will be made within the next two months.

★ ★ ★

West Coast Statistical office of the Bureau of Mines will remain in uninterrupted operation although Congress has reduced its appropriation by one-half. R. A. Catell, chief of the petroleum economics branch of the bureau, indicates that economists in their operations of his departments will enable the statistical office to function at full strength for the rest of the fiscal year. "If we do not (have normal budget restored next year), we must prepare either to close the West Coast office or operate it on money contributed by industry."

★ ★ ★

Employee "fringe" benefits in the oil industry exceeded $1275 per workman in 1955, according to the biennial survey of the U. S. Chamber of Commerce. This covers all payments that are not a part of direct wages such as bonuses, social security, pensions, paid rest periods, holiday pay, etc. As usual, the oil industry ranked at the top of all industries in the survey and was the only manufacturing industry with "fringes" above $1000 per year. The amount represents nearly one-fourth of the total payroll of costs in the industry.

★ ★ ★

Standard Oil Company (Indiana) received the Public Relations News annual achievement award for outstanding contributions to professional and management public relations during 1955. The publication singled out the company's handling of the news of the Whiting, Indiana, refinery disaster on August 27, 1955. Award was presented by Denny Griswold, editor and publisher of Public Relations News and accepted by Dr. Robert E. Wilson, chairman of the board of Indiana Standard.

Education for this age of automation will get a boost during Automation Week in New York, November 26-30. It is expected that several thousand executives, engineers and technical men will become students at the Third International Automation Exposition. "School" will be conducted on five full floors of New York's Trade Show building for six sessions each of 54 different clinics on basic instruction in automation equipment for offices, laboratories, processing and manufacturing plants.

★ ★ ★

Five British industrial groups have evolved designs for an atomic-powered tanker that would need refueling only every two years, in an attempt to head-off any interruption in service through the Suez Canal. British ship designers, already outpacing U. S. and Russia in this field, have stepped up work on atomic powered ships, as well as atomic power stations. First power station using nuclear energy in Great Britain went into operation in October.

★ ★ ★

Shale oil extraction method, called the Aspeco process and developed in Sweden, is being tested by scientists at the University of Denver's Research Institute in Colorado. Most of the problems have been solved through the evaluation of a pre-pilot plant, scienitsts say, and contract has been let for a pilot plant to be built in south Denver. Cost of the project is said to run near $250,000.

★ ★ ★

Don't worry about the gas turbine engine — yet, Chrysler Corporation President L. L. Colbert has assured the oil industry. Speaking at the recent Texas Mid-Continent Oil & Gas Association, Colbert said the most optimistic estimates of the future car population may fall far short if the automobile industry comes up with a lighter, quieter, more responsive engine than we now have. If the engine turns out to be the gas turbine, Colbert pointed out, "you in the petroleum industry might find yourselves taking a much broader cut out of a barrel of crude oil than you do in producing present day automotive fuel. This would seem to us to be very much to the long-range advantages of the nation in making the most of our petroleum reserves."

Union workers in the oil industry will be asking for wage boosts soon, says O. A. Knight, president of the Oil, Chemical and Atomic Workers International Union. Last general increase was last February, Knight indicated, when average hourly pay was hiked from $2.47 to $2.65 in oil refineries, where most oil union members are employed. Knight said he will recommend a new wage plan to the union's bargaining policy committee meeting in Denver, Colorado, December 7.

★ ★ ★

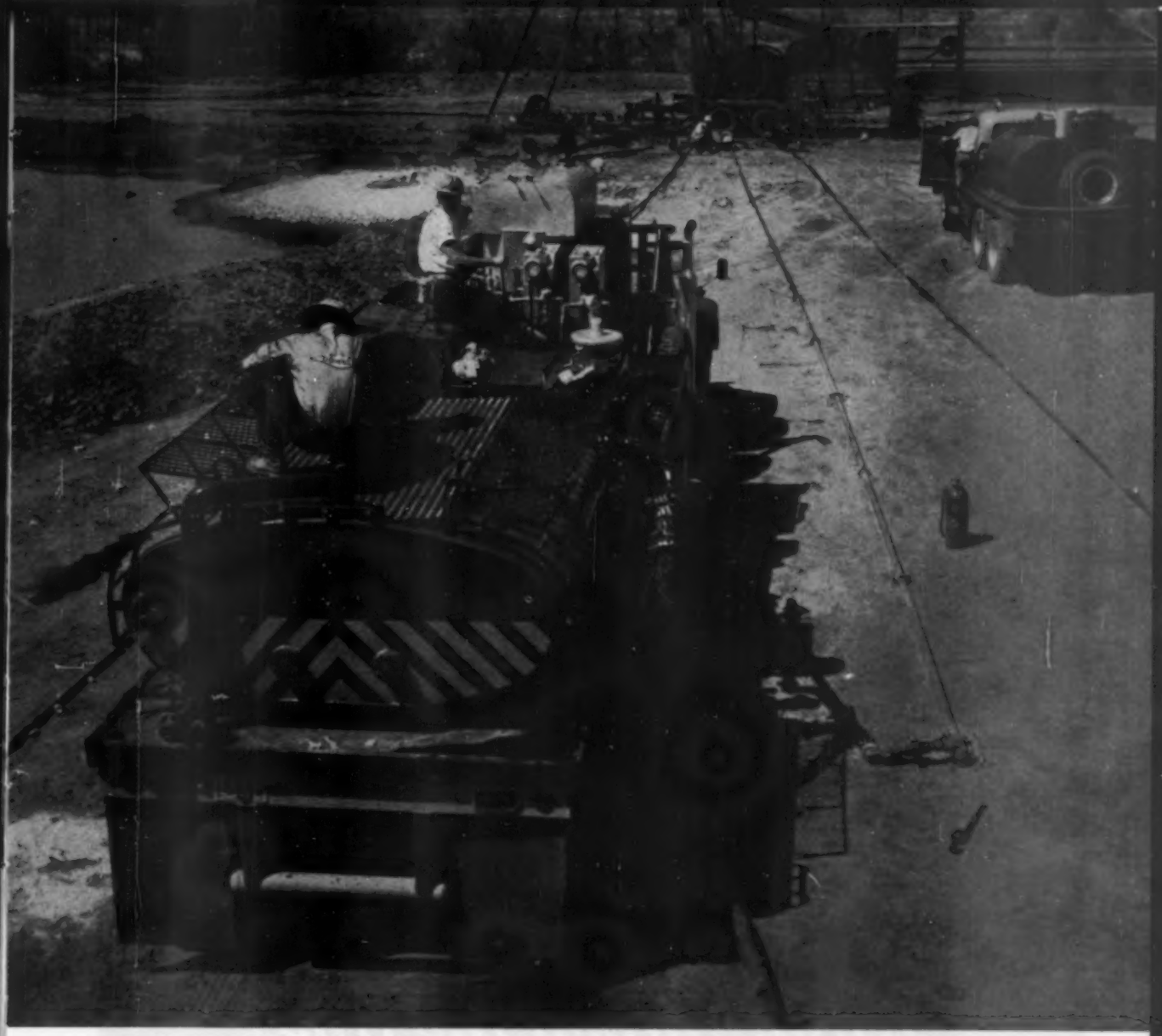
FPC's permission to Texas Eastern Transmission Corporation to take imports of Mexican natural gas at the rate of 14.2 cents per Mcf has given rise to demand by Texas and Mid-Continent gas producers for better wellhead prices. Most producers receive several cents less per thousand than the price given Pemex for its imported gas. Independent producers have reasoned that "if the gas is worth that much to buy it out of this country, it should be worth as much to domestic producers."

★ ★ ★

Guaranteed profit margin to gasoline retailer of 6 cents per gallon — after rent—has been asked by John A. Touhey, Southern California Service Station Association executive secretary, declaring that it would end price wars and cost not more than the "subsidies, rebates and special allowances which foster those wars." The majority of retailers, Touhey believes, would like to see fair trading initiated on a sound basis, but to be successful, "it must begin at the rack and extend to every level."

★ ★ ★

Office of Defense Mobilization will keep its present formula limiting oil imports, but has been warned that unless incoming shipments are cut voluntarily the inflow will represent a threat to national security. Director Arthur Fleming said the President's Cabinet Committee on Energy Supplies and Resources has reviewed the question and decided to keep the present formula by which imports, except those from Canada and Venezuela, are held to approximately the same proportion of domestic crude oil production as in 1954. In effect, compliance with the new order would mean reduction of imports by about one per cent from their imports in the first half of 1955 — a decrease of about 3000 bbl daily below a scheduled import rate of 302,600.



DOWELL ENGINEERS USE SILICATE CONTROL ACID TO PREVENT FORMATION CLOGGING—MAKE ACIDIZING TREATMENT MORE EFFECTIVE.

Silicates won't block production here

SILICATE CONTROL ACID is a Dowell development for improving acidizing effectiveness.

During ordinary acidizing treatments clays and other silicate minerals in the formation may swell and block oil passages. Dowell engineers use Silicate Control Acid to prevent this.

An oil film is formed around the particles to reduce swelling. This results in increased permeability. The spent acid can then return to the well bore — more easily and more completely. Silicate Control Acid also decreases troublesome oil-in-water emulsions.

Don't let pore-clogging silicates cause you trouble. Before your next well treatment check with a Dowell engineer. He can tailor each treatment to fit well conditions — giving you maximum results per investment dollar.

For more information or service, call any of the 165 Dowell offices in the United States and Canada; in Venezuela, contact United Oilwell Service. Or write to Dowell Incorporated, Tulsa 1, Oklahoma, Dept. K-12.

services for the oil industry

DOWELL

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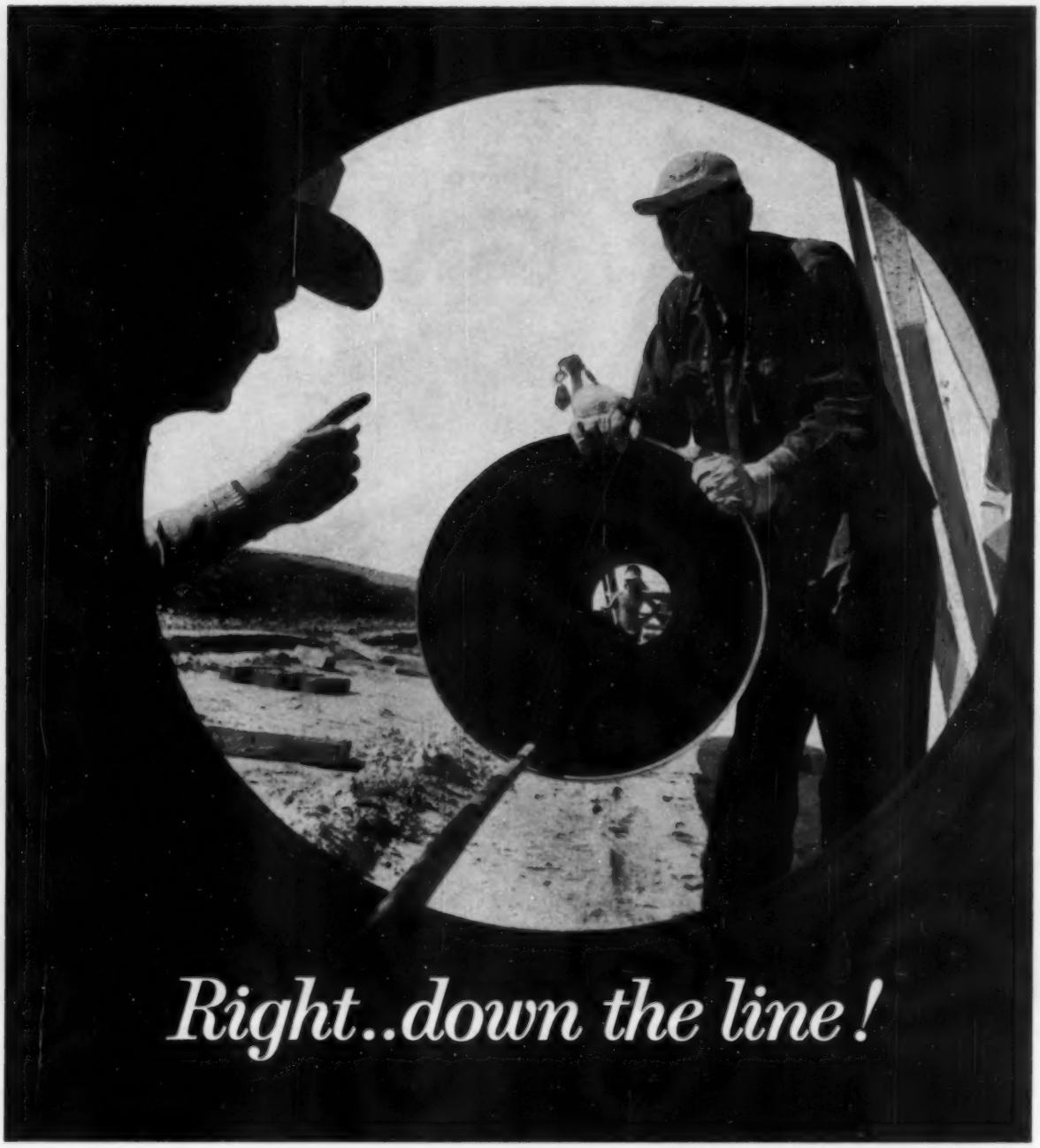


PACIFIC NORTHWEST PIPELINE CORPORATION PHOTOGRAPH.

Quality, uniformity, precision—these are watchwords that you can always depend on when you use Kaiser Steel Line Pipe.

For example, Kaiser Steel Line Pipe—20 inch OD and larger—is placed in restraining dies and expanded by water under great pressure. This hydraulic expansion assures accurate diameter, concentricity and straightness—and also strengthens the pipe through additional cold working. Another example of the painstaking care that goes into the manufacture of pipe from Kaiser Steel.

Next time you are ordering line pipe, specify Kaiser Steel Line Pipe. Rely on Kaiser Steel quality and service to add dollars to your operating profits.

Kaiser Steel

Steel Mill Products: plates • hot rolled strip and sheet • cold rolled strip and sheet • tin plate • continuous weld pipe • electric weld pipe • alloy and carbon bars • bar shapes • structural shapes semi-finished steels • pig iron • ingot molds • coke by-products • **Fabricating Division:** steel fabrication for construction, aircraft, missile and other industries • expanded fusion weld pipe reinforced concrete pipe • tanks • For specifications, write: **KAISER STEEL CORPORATION** • **Los Angeles** • **Oakland** • **Seattle** • **Portland** • **Phoenix** • **Denver** • **Tulsa** • **New York**

Meetings

Nov. 1-2—**Louisiana Polytechnic Institute,** School of Engineering, 5th annual Instrumentation Conference, on campus, Ruston, Louisiana.

Nov. 1-2—**Society of Automotive Engineers,** national diesel engine meeting, Drake Hotel, Chicago, Illinois.

Nov. 2—**AIME, Pittsburgh Section,** annual off-the-record meeting, William Penn Hotel, Pittsburgh, Pennsylvania.

Nov. 5-7—**Canadian Institute of Mining & Metallurgy,** annual western meeting, Vancouver Hotel, Vancouver, British Columbia.

No. 7-9—**Steel Founders' Society of America,** 11th annual technical and operating conference, Carter Hotel, Cleveland, Ohio.

Nov. 7-10—**SAMA Laboratory Apparatus and Optical Sections,** midyear meeting, The Homestead, Hot Springs, Virginia.

Nov. 8-9—**American Association of Oilwell Drilling Contractors,** 11th annual safety clinic, Statler-Hilton Hotel, Dallas, Texas.

Nov. 8-9—**Society of Automotive Engineers,** national fuels and lubricants meeting, The Mayo Hotel, Tulsa, Oklahoma.

Nov. 8-9—**AAPG, Society of Exploration Geophysicists, SEPM,** fall meeting, Ambassador Hotel, Los Angeles, California.

Nov. 8-9—**National Association of Corrosion Engineers,** southeast region meeting, Charlotte, North Carolina.

Nov. 8-10—**AIME, mining branch,** northeast regional meeting, Hotel Hershey, Hershey, Pennsylvania.

Nov. 12—**API OIIC Steering Committee,** Conrad Hilton Hotel, Chicago, Illinois.

Nov. 12-15—**American Petroleum Institute,** 36th annual meeting, Conrad Hilton Hotel and Palmer House, Chicago, Illinois.

Nov. 13-14—**API board of directors,** Conrad Hilton Hotel, Chicago, Illinois.

Nov. 14—**API board of directors, executive committee,** Conrad Hilton Hotel, Chicago, Illinois.

Nov. 15-16—**National Association of Corrosion Engineers,** western regional division conference, Lafayette Hotel, Long Beach, California.

Nov. 19-20—**American Petroleum Credit Association,** 19th annual meeting, Broadview Hotel, New York City.

Nov. 19-20—**North Texas Secondary Recovery Symposium,** Petroleum branch, AIME, Municipal Auditorium, Wichita Falls, Texas.

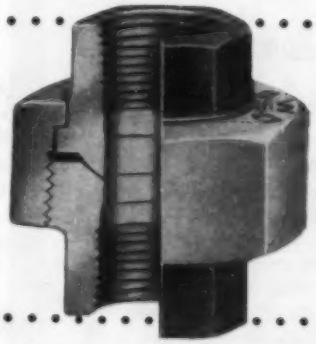
Nov. 25-30—**American Society of Mechanical Engineers,** Statler Hotel, New York City.

Nov. 26-30—**Third International Automation Exposition,** Trade Show Building, New York City.

Nov. 27-30—**National Chemical Exposition,** 9th trade show, Cleveland Public Auditorium, Cleveland, Ohio.

W-S FORGED STEEL UNIONS...

These Features are YOUR GUARANTEE of a Safe, Tight Union Connection:



1. FORGED STEEL CONSTRUCTION— ASTM A-105, GRADE 2
2. SPHERICAL-TO-ANGLE MATING SURFACES
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W-S Forged Steel Unions give you the kind of protection you need in high pressure piping systems. They're designed with precision-machined spherical-to-angle mating surfaces for positive seating, free from leaks even when pipes are slightly out of line. Cadmium-plated nuts resist galling and seizing and forged steel construction gives you the extra strength you need in high pressure service.

W-S Unions are available in 3000 lb. class, sizes ⅛" to 3" in screw-end and socket-welding types. Send today for your copy of Bulletin U-1.

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You get Full Season's Control from One Application!

Only barren soil is safe from fire and other hazards! UREABOR destroys most all vegetation ... for long periods. As little as 1 to 2 lbs. per 100 sq. ft. does this. Such low application rates mean savings on labor and storage space. UREABOR Weed Killer is always ready to use—DRY. Broadcast it by hand for spot treatments ... use the handy new PCB Spreader for larger areas.

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The new PCB Spreader is made for easy and efficient application of Ureabor. Available at $10.75—delivered—anywhere in the U.S.A.

Use UREABOR to destroy vegetation about fence lines, well sites, pipe lines, refinery buildings, heater units, tank batteries, and all places where ground must be kept bare.

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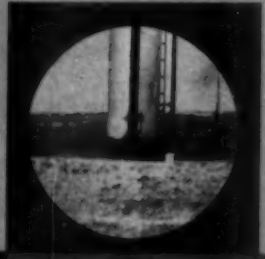

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When applied as directed

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To ferrous metals

AGRICULTURAL SALES DEPARTMENT
United States Borax & Chemical Corporation
PACIFIC COAST BORAX COMPANY DIVISION
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Nov. 28-30—**Illinois Institute of Technology,** international ozone conference, Sheraton Hotel, Chicago, Illinois.

Nov. 29-Dec. 1—**Interstate Oil Compact Commission,** annual meeting, Allis Hotel, Wichita, Kansas.

Dec. 3-4—**New Mexico Oil & Gas Association,** annual meeting, Alvarado Hotel, Albuquerque, New Mexico.

Dec. 3-5—**APCA,** semi-annual meeting, Rice Hotel, Houston, Texas.

Dec. 5-6—**The Asphalt Institute,** annual meeting.

Dec. 6-7—**API Oil Industry Information Committee,** Biltmore Hotel, New York City.

Dec. 6-8—**Interstate Oil Compact Commission,** annual meeting, Fontainebleau Hotel, Miami Beach, Florida.

Dec. 9-12—**American Institute of Chemical Engineers,** annual meeting, Statler Hotel, Boston, Massachusetts.

Dec. 16-18—**Kansas Independent Oil & Gas Association,** annual meeting, Broadview Hotel, Wichita, Kansas.

1957

Jan. 14-16—**Pipe Line Contractors Association,** Boca Raton Hotel and Club, Boca Raton, Florida.

Jan. 28-31—**Plant Maintenance and Engineering Show,** Public Auditorium, Cleveland, Ohio.

Jan. 21-25—**American Institute of Electrical Engineers,** 1957 winter general, Hotel Statler, New York City.

Feb. 8-9—**API symposium,** Jung Hotel, New Orleans, Louisiana.

Feb. 13-15—**National Association of Corrosion Engineers,** 8th annual corrosion course for pipeliners, Mayo Hotel, Tulsa, Oklahoma.

Feb. 24-28—**American Institute of Mining, Metallurgical, and Petroleum Engineers,** annual meeting, Hotels Roosevelt and Jung, New Orleans, Louisiana.

Feb. 26-27—**API Division of Marketing,** lubrication committee, Sheraton-Cadillac Hotel, Detroit, Michigan.

March 20-22—**API Division of Production,** southern district meeting, Washington Youree & Captain Shreve Hotels, Shreveport, Louisiana.

March 21-22—**American Trade Association Executives,** 1957 Washington conference, Mayflower Hotel, Washington, D. C.

March 27-29—**American Power Conference,** Sherman Hotel, Chicago, Illinois.

April 1-4—**AAPG,** national convention, Kiel Auditorium, St. Louis, Missouri.

April 8-9—**Industrial Accident Prevention Association,** annual conference, Royal York Hotel, Toronto, Canada.

April 24-26—**Natural Gasoline Association of America,** 36th annual convention, Rice Hotel, Houston, Texas.

Oct. 9-10—**Third Annual Computer Applications Symposium,** sponsored by Armour Research Foundation of Illinois Institute of Technology, Morrison Hotel, Chicago, Illinois.

Nov. 30-Dec. 1—**Executive Committee of Interstate Oil Compact Commission,** Wichita, Kansas.

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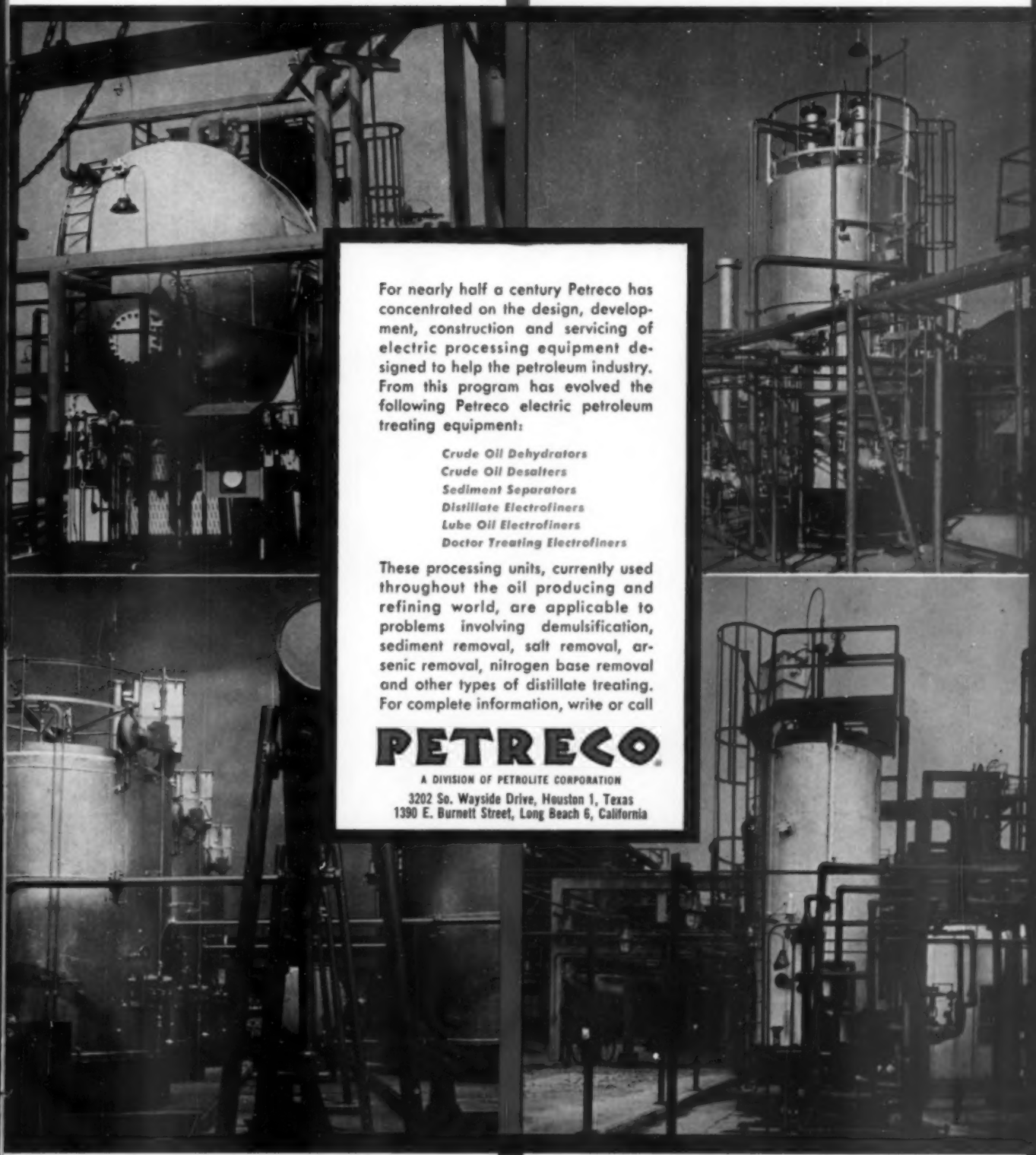

For nearly half a century Petreco has concentrated on the design, development, construction and servicing of electric processing equipment designed to help the petroleum industry. From this program has evolved the following Petreco electric petroleum treating equipment:

Crude Oil Dehydrators
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These processing units, currently used throughout the oil producing and refining world, are applicable to problems involving demulsification, sediment removal, salt removal, arsenic removal, nitrogen base removal and other types of distillate treating. For complete information, write or call

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The economy of perfection—saves money, time, and trouble—with the installation of OTM's Blue Ribbon flanges, weld necks, welding fittings, and ring gaskets. The most modern electronic inspection methods guarantee absolute perfection.
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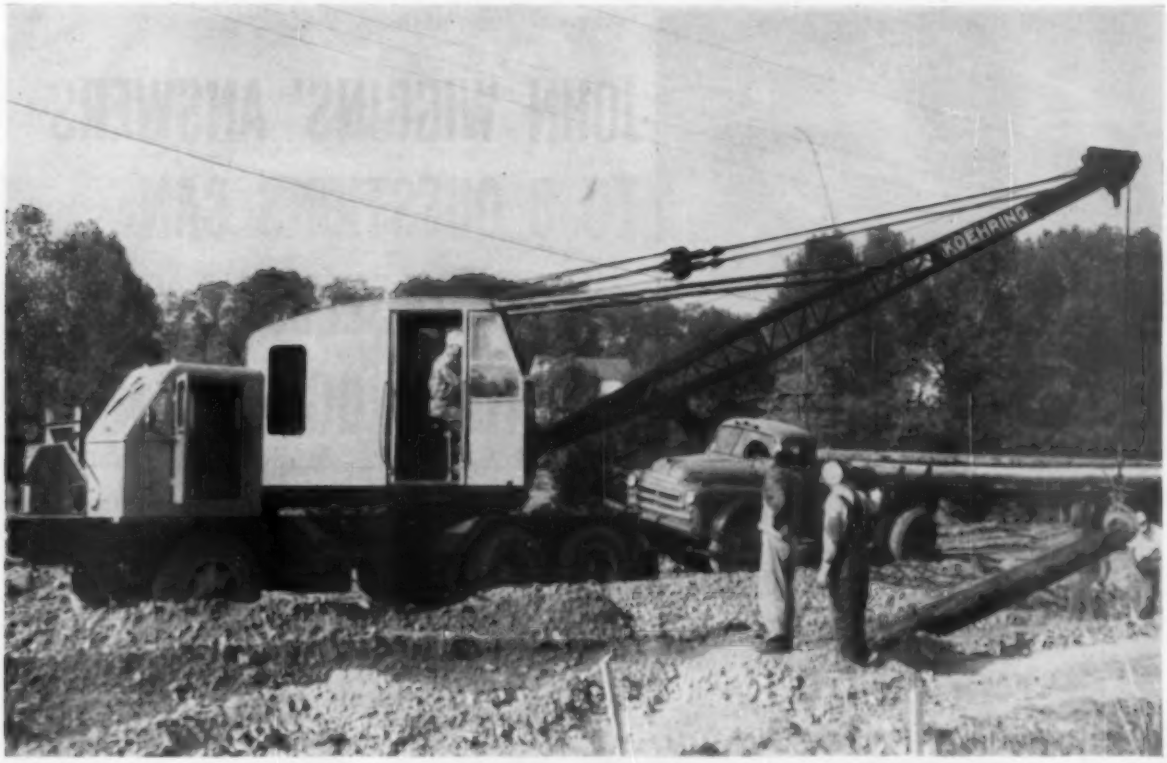


On lifting and material-handling work, where distance between jobs is a problem, take advantage of the speed, mobility, and *extra capacity* of Koehring 205 Truck Crane. It travels anywhere a truck will go — can be 30 miles from here in less than an hour from "now".

With one of these mobile cranes, you're equipped to lift any load up to 15 tons (based on 85% of tipping load). For high lifts, 25-foot boom can be lengthened to 70 feet. For extra reach, 15 to 30-ft. jib can be added to 65-foot boom. Stability of truck mounting increases the 205's work capacity with every attachment. It handles ½ to ¾-yard clamshell or dragline buckets on a wide work-radius — and quickly converts to ½-yard shovel or hoe.

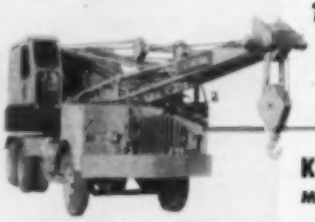
This heavy-duty 205 also is available as a 15-ton Cruiser® crane, or 10-ton crawler crane — with all standard attachments. On rubber-tired Cruiser mounting, it brings you travel speeds up to 21½ m.p.h. — plus one-man operation for both work and travel.

Next time you're in the market for a crane or excavator, look into this 205. Your Koehring distributor has complete facts and figures that will interest you. Why not call him today? Or, use coupon to get complete information by mail.

You get 15-TON LIFT CAPACITY

32 1/2 mph mobility

with this 205 Truck Crane



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JOHN WIGGINS' ANSWERS TO 8 QUESTIONS CAN HELP YOU SELECT A BETTER FLOATING ROOF SEAL

Are all floating roof seals the same? What about safety? Conservation? We asked John Wiggins, inventor of the floating roof and noted conservation authority, to answer questions most commonly asked about the new Wiggins Safety Seal.

1—**Q.** In the new Wiggins Safety Seal does any of the mechanism contact the liquid?

A. No. All metal working parts are out of the liquid away from corrosive vapors.

2—**Q.** Does the new "Weather Hood" provide longer fabric life?

A. Yes—the fabric is protected from the sun and other elements—lower temperature under the hood provides added conservation.

3—**Q.** In old style seals, rust and scale accumulate and shorten seal life. Does this happen with this seal?

A. The "Weather Hood" prevents rust and scale from depositing in the "seal loop"—thereby increasing seal life.

4—**Q.** Does the Wiggins Safety Seal prevent rim fires?

A. Yes—design of the seal virtually eliminates critical vapor spaces where air and vapor collect to form explosive mixtures. When exploded through controlled tests, the fabric was able to expand enough to contain the explosion without tearing.

5—**Q.** Is this seal safe for the storage of low vapor-pressure, low flash-point liquids such as jet fuels?

A. Yes, the design of the Wiggins Safety Seal reduces the danger area to a minimum so that it can be used in the storage of jet fuels with complete confidence.

6—**Q.** How does the Wiggins Safety Seal guarantee maximum protection against evaporation loss?

A. Air-vapor volume of the Safety Seal is less than 10% of the present volume for floating roof seals. This would eliminate most losses. In addition, the air-vapor space is shielded by a "Weather Hood". This area—the area that breathes—reduces losses to a minimum.

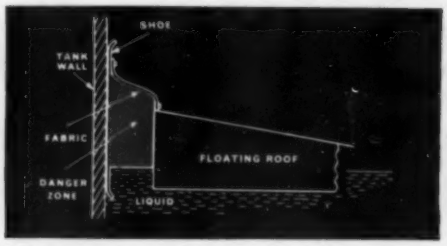
7—**Q.** Will the Wiggins Safety Seal save me money?

A. Yes—by eliminating losses due to thermal breathing, preventing rim fires, use of new longer-lived fabric, protecting the mechanism from liquid and corrosive vapors and permitting much longer periods of "in-service" operation.

8—**Q.** Why have you put so much emphasis on the seal?

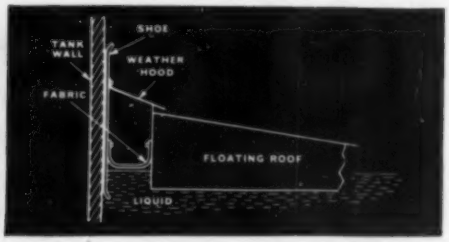
A. A floating roof is only as safe as its seal. With the new Wiggins Safety Seal, Wiggins floating roofs are in a class by themselves. Since General American makes all types of floating roofs, you can have the Wiggins Safety Seal on the roof that best meets your needs—whether it be the Wiggins Hidek*·Lodek* or Doubledek*.

*Patented



OLD

With the old type seal, the fabric is exposed to the sun's rays and explosive vapor collects in the large space between the liquid and the fabric; the mechanism is submerged in the liquid and exposed to corrosive vapors.



NEW

With the new Wiggins Safety Seal, vapor space under the circumferential fabric is reduced to a minimum. Ends spark fire hazards. Fabric is protected from the sun. Mechanism is out of liquid and corrosive vapor space.

To see why Wiggins Floating Roofs pay for themselves, write or call your General American sales engineer.

PLATE AND WELDING DIVISION

GENERAL AMERICAN TRANSPORTATION CORPORATION

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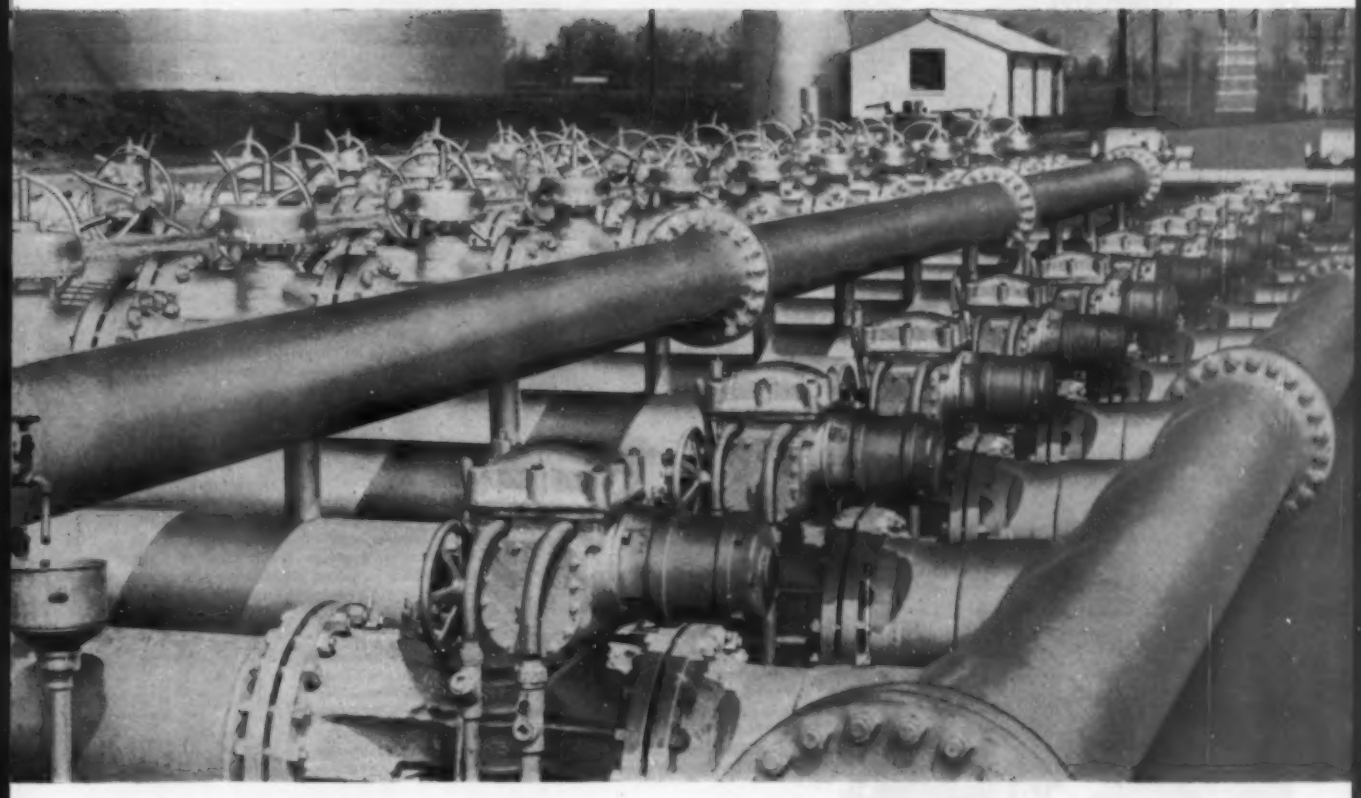

ROCKWELL-Nordstrom VALVES

close faster, easier and stay tight!

The faster and easier a valve closes, the simpler and less costly its power mechanism can be. Rockwell-Nordstrom valves close faster—only a quarter-turn—and easier, because they are lubricated. Compare this to the many turns required to close ordinary valves and the excessive torque for wedging-in the seats. It's easy to see why Rockwell-Nordstrom lubricated plug valves have proven to be the most reliable and most economical valves for automatic pipeline control.

Rockwell-Nordstrom valves are available in a complete range of sizes from ½″ to 30″ and in pressure ratings from 175 to 1440 lbs for electric cylinder and pneumatic operation. Write today for more information. Rockwell Manufacturing Company, Pittsburgh 8, Pa.

Canadian Valve Licensee: Peacock Brothers Limited

ROCKWELL-Nordstrom VALVES

Lubricant Sealed for Positive Shut-off

40th YEAR *of lubricated plug valve leadership*

Where leakage cannot be tolerated...

Soils of resistivities under about 2,000 ohm-cm, or soils of widely varying resistivities averaging even 5,000 ohm-cm or more, are usually quite corrosive. For such soils Somastic® Pipe Coating is the ideal solution. To avoid the expense of frequent changes in pipe treating equipment and crews on long lines, Somastic Pipe Coating should be used in sections of perhaps five to ten miles minimum length through such soils, even though intermediate stretches were of higher resistivity.

Wherever pipe lines traverse city streets and subdivisions or valuable agricultural property, or lands that may soon be converted to such use, Somastic Pipe Coating is recommended. This added precaution is a good investment against the cost and public ill will that would result from a leak, even though soil studies may not indicate that severe corrosion should be anticipated. A further factor in such locations is that supplementary cathodic protection may not be feasible on poor coating because of the difficulty of obtaining suitable anode locations.

Somastic Pipe Coating has long been the standard for swamp construction, river and harbor crossings, and coated submarine lines. Experience indicates that submarine lines and river crossings can be installed when Somastic Pipe Coating is used without the expensive handling precautions normally required for other coatings. Examples of such use can be supplied including submarine lines in the Persian Gulf, in Lake Maracaibo and in the Pacific.

Although Somastic Pipe Coating can be damaged by unusually rough handling, it is true that it can be installed with a minimum of damage under conditions of mountainous terrain where prewrapped coatings would be damaged in handling and where over-the-trench machines cannot satisfactorily negotiate. Somastic Pipe Coating is usually the best choice when such construction problems are encountered.

Pipe lines are occasionally run through watersheds or river valleys where it is essential that every precaution be taken to prevent leaks. Such locations are an excellent application of Somastic Pipe Coating both because of the protection the coating affords and the evidence given to public authorities and others that the best possible pipe protection is being used.

you'll save money with SOMASTIC® coated pipe lines

SOMASTIC PIPE COATING is available in a number of formulations. Each is an asphalt-mastic designed for continuous, uniform, seamless, impermeable protection.

SOMASTIC PIPE COATING is *thick*. There are fewer pits under thick coatings. It is *seamless*. There are no holidays because of overlapping layers or bubbles. It is *reinforced*. The reinforcement is permanent and uniform. It is *rigid yet elastic* . . . withstands depression over long periods, absorbs pipe movement and changes in pipe line temperature. *Proved* under adverse soil conditions for more than 24 years. *That's why Somastic Pipe Coating will save you money wherever leakage cannot be tolerated!*

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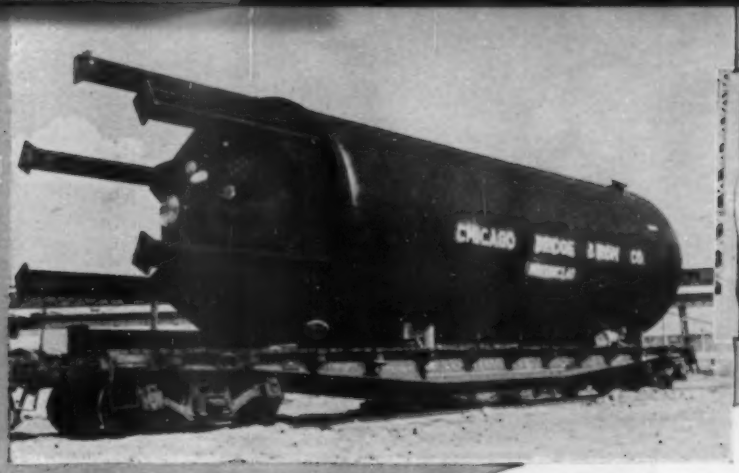


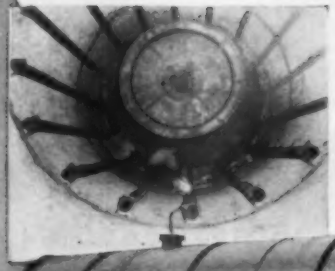
Left: 12-ft. O.D. by 43-ft. 4-in. digester with 316 E.L.C. Hortonclad. Inset: Interior of vessel built for Hudson Pulp and Paper Company at Palatka, Florida.

HORTONCLAD and CB&I VESSELS

High Vacuum Brazing Process Assures Uniform Thickness of Clad Layer

Hortonclad®, available only with CB&I process and storage vessels, is a composite metal having an integral and continuous bond produced by a high vacuum brazing process. Uniform thickness is assured as the alloy cladding and the backing are in their final thickness before bonding. Hortonclad meets all ASME boiler code and API-ASME Unfired Pressure Vessel Code requirements.

CB&I vessels can be fabricated using Hortonclad plates with silver, monel, Inconel, Hastaloy, stainless and a wide variety of other metals and alloys. Complete information on Hortonclad and its use with CB&I vessels may be obtained by writing our nearest office.



Above: A 36-ft. 9 13/16-in. shell section of this 43-ft. reactor has type 405 stainless steel Hortonclad. Inset: View inside of reactor supplied to the Derby Oil and Gas Co., Wichita, Kansas, through the Fluor Corp.

Above: 37 1/4-in. O.D. by 24-ft. 10 5/8-in. urea autoclave liner with fine silver Hortonclad. Inset: View of interior.

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Teeth that really dig!

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H&L TOOTH COMPANY

1540 South Greenwood Avenue,
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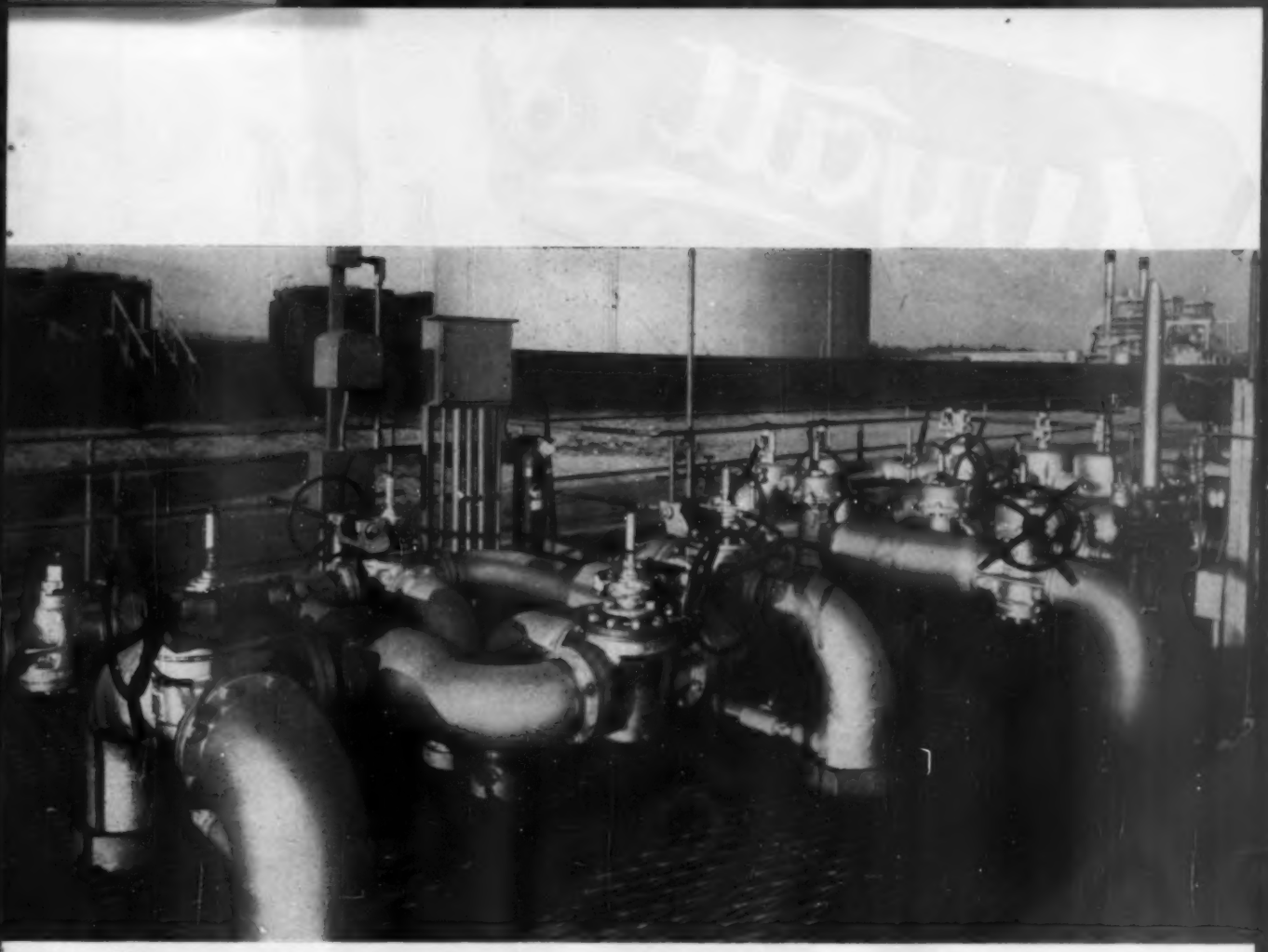
25th Silver Anniversary



flow control at its best

Rockwell-Nordstrom valves are safe, dependable and economical on *any* petroleum processing operation. The key to Rockwell-Nordstrom's forty years of leadership is the unique Sealdport* pressurized lubricant sealing system for *positive shut-off* on lightest hydrocarbons or heavy crudes. Pressurized lubricant also jacks the plug for instant, quarter-turn operation and eliminates metal-to-metal friction for lowest down time and maintenance costs.

Rockwell-Nordstrom, the *original* lubricated plug valve, is available in semi-steel, steel, stainless and corrosion resisting metals in sizes up to 30″ x 36″. For more data, contact any leading distributor or write: Rockwell Manufacturing Company, Pittsburgh 8, Pennsylvania.

Canadian Valve Licensee: Peacock Brothers Limited

*Registered Trade Mark, Rockwell Manufacturing Company

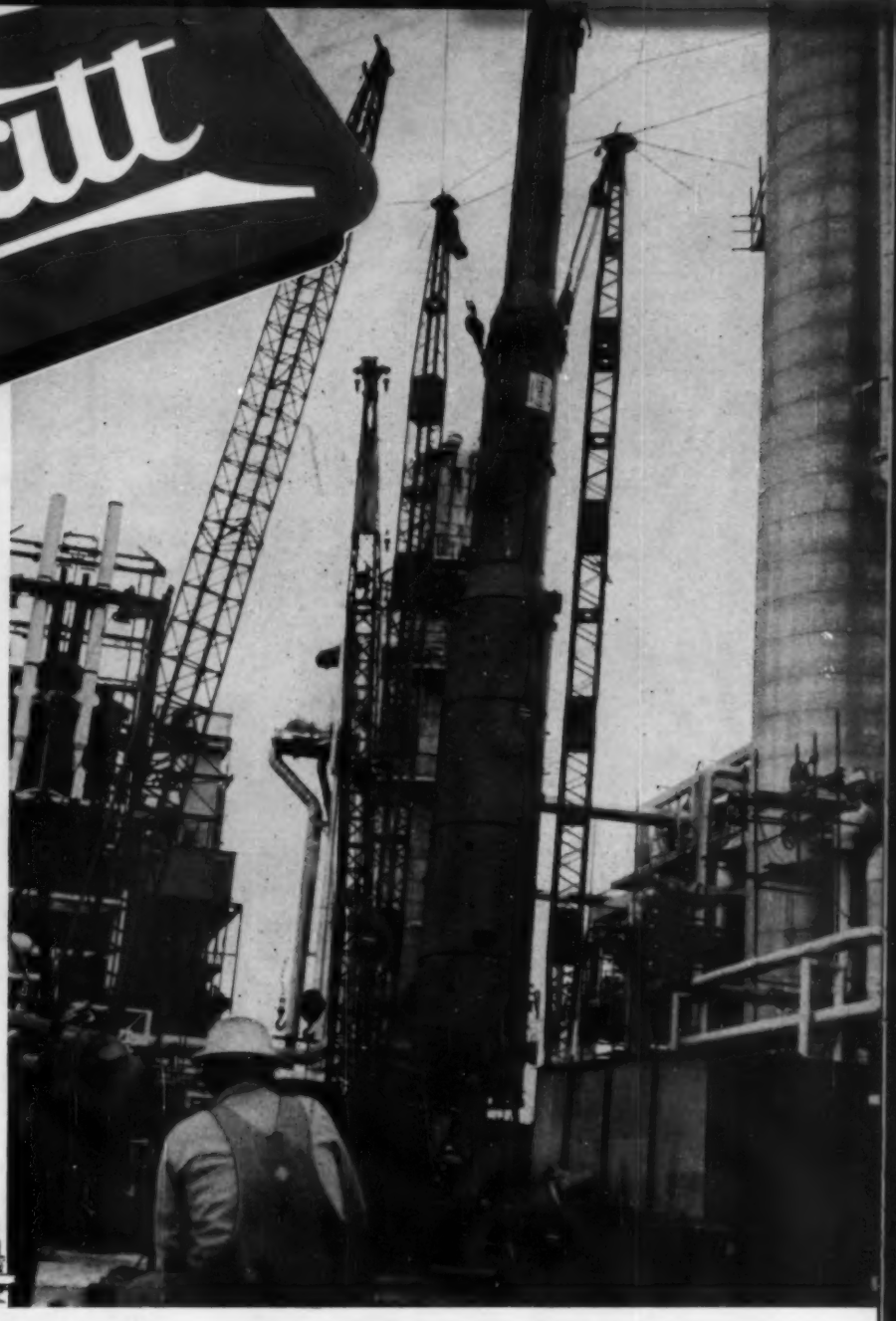
ROCKWELL-Nordstrom VALVES

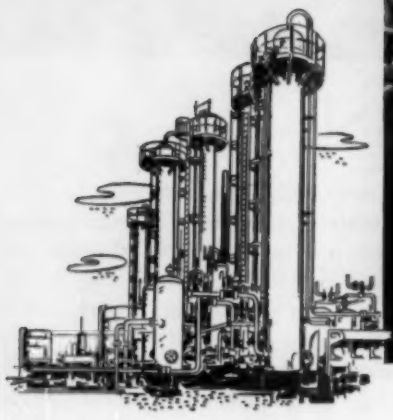
Lubricant Sealed for Positive Shut-off

40th Year *of lubricated plug valve leadership*

Wyatt

...will be there





• Just how the Petroleum Industry is going to meet the requirement of doubling its refining capacity in the next twenty years is beyond our calculation.

What we do know is that it will call for Wyatt's shops to keep moving pressure vessels into refining plants the country over, as this one is going into service in the Lake Charles plant of Cities Service Refining Corporation.

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New Copper Deactivator Guaranteed not to freeze!

This special all-weather UOP Copper Deactivator formulation will not freeze when stored for extended periods at temperatures down to 0° F. We call it Copper Deactivator-AW(50)*, since it contains active ingredient in 50% concentration. This new formulation completely eliminates the low temperature pumping problems common to other deactivators.

AW(50) gives maximum metal deactivating efficiency and economy. Improved color, too, and because of its better solubility and pumping properties, it can be injected directly into gasoline or other refinery streams without the customary dilution with aromatic spirits.

AW(50) is supplied in handy five-gallon containers for manual addition or blending with other additives and in 55-gallon drums for automatic injection systems.

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PRODUCTS DEPARTMENT

UNIVERSAL OIL PRODUCTS COMPANY

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Regulators and relief valves give positive accurate control

- Control outlet pressure within narrow limits up to full rated capacity
- Positive bubble-tight seal unaffected by presence of foreign matter
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- Less maintenance, with no sticking, friction, or corrosion problems
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- Proved in service with gas, air, water, oil and other fluid services
- Effective with temperatures to 150F and working pressures to 1500 psi
- Grove Flexflo Valves and Regulators available in iron or steel, 1" to 12"

The only moving part of the Grove Flexflo is an expansible tube which outlasts ordinary valve mechanisms many times over. Serving both as diaphragm and valve, it is instantly responsive, and closes tightly over scale or foreign matter without leakage or damage. For compactness, high capacity in relation to size, smooth sure control, and low maintenance, specify Grove Flexflo Valves and Regulators for pressure reduction, back pressure or relief services.

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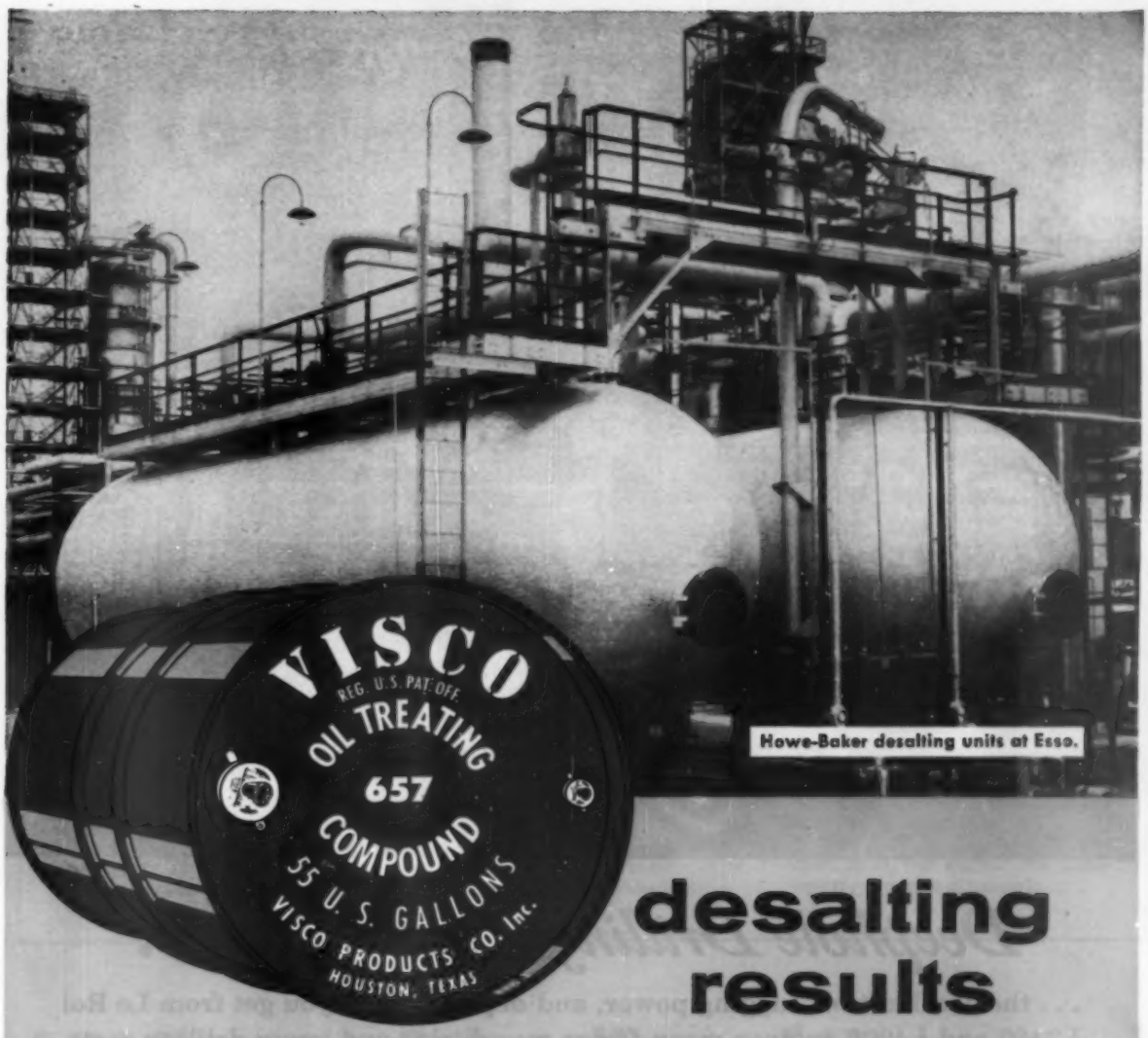

Howe-Baker desalting units at Esso.

desalting results

. . . a foregone conclusion at Esso's Bayway Refinery

The modern equipment shown above is one of the recent additions to the Esso Standard Oil Company Refinery at Linden, New Jersey.

With equipment such as this, plus the familiar blue barrels of Visco, outstanding desalting results are a foregone conclusion.

Visco, in either electrical or salt settling equipment, still provides the consistently efficient — and economical — chemical solution to the problem of greater throughput and lower corrosion costs.

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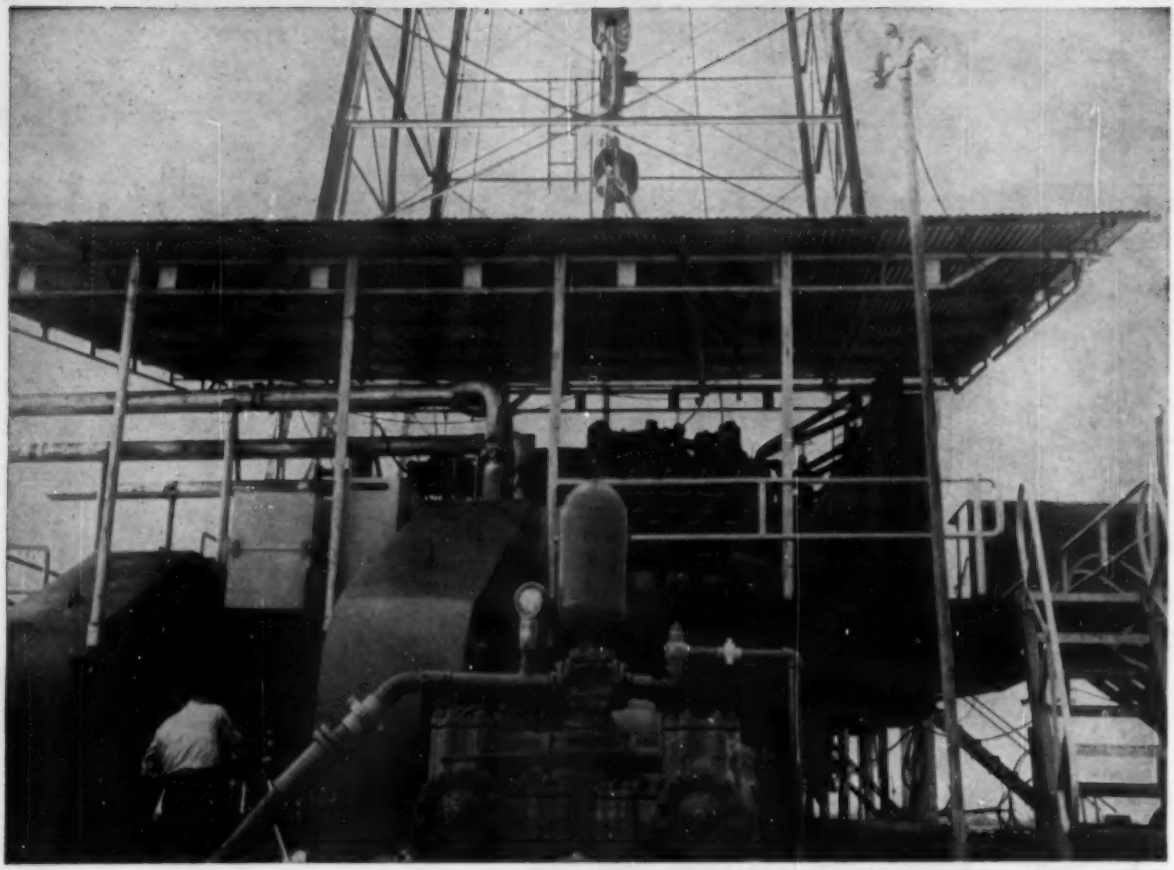
Visco CONSISTENTLY EFFICIENT OIL INDUSTRY CHEMICALS



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. . . the acceleration, lugging power, and dependability you get from Le Roi L3460 and L4000 engines mean faster round trips and lower drilling costs.

WHEN you have to go deep you need plenty of horsepower. And the place to get it is from Le Roi's L3460 with 600 max. hp. or its big brother, the L4000 with 655 max. hp.

You get much more, too. You get compactness. These V-12 overhead-valve engines are only 164 in. long. That makes them ideal for drill-rig installation, because they pack a lot of power in a small space — give you more horsepower per dollar.

But that's not all you get from these high-output engines. They represent the first, truly new design concept in 15 years. They have improved fuel economy; integral crankcase and cylinder construction for greater rigidity; longer bearing life; hydraulic valve lifters; better manifolding; husky crankshaft with integrally forged counterweights for unbelievably smooth operation — modern features that mean lightning response to load demands, outstanding performance and dependability.

Like all Le Roi engines, they're built to stand oilfield handling; they're easy to service; they have a wide speed range up to 1350 rpm; and they operate on natural gas, butane, or gasoline.

Ask your supply house or Le Roi distributor to show you an L3460 or L4000 at work. See for yourself why they can help you make hole faster. Literature is also available — just write us for it.

P-139

LE ROI *Division of Westinghouse Air Brake Co.*

Milwaukee 1, Wisconsin

PORTABLE AIR COMPRESSORS · TRACTAIR · STATIONARY AIR COMPRESSORS · AIR TOOLS · ENGINES

Frank H. Willibrand, Chairman of the API Central Committee on Training, is manager of operations for Sohio Petroleum Company, making his headquarters in Oklahoma City, Oklahoma. His association with the oil industry dates back to 1919 when he was employed by Shell Oil Company in California. He worked for that company until 1927 when he entered the University of Oklahoma. After obtaining his degree in petroleum engineering he joined Phillips Petroleum Company. Shortly before Pearl Harbor he left Phillips and went with Sunray as district superintendent in the Corpus Christi area. During World War II he worked in the PAW Production Division, and in 1943 opened Sohio's Oklahoma City office. He is a member of Tau Beta Pi, engineering fraternity.

R. E. Foss, Chairman, API Committee on Vocational Training, is vice president of Sunray Mid-Continent Oil Company, Tulsa, Oklahoma. With a mechanical engineering degree from the California Institute of Technology, he went to work in the California oil fields as a roughneck during the depression years. In 1935, three years later, he joined the Barnsdall Oil Company as a junior engineer.

Successively he became Barnsdall's chief engineer, California production superintendent, and vice president in charge of West Coast production operations, which position he held when Barnsdall was merged with Sunray in 1950.

In addition to his vocational training chairmanship with API, he also serves on the the general committee of the Division of Production.

Robert W. McIlvain, Jr., Chairman, API Committee on Supervisory Development, is vice president of Pure Oil Company, Chicago, Illinois. He was graduated from Sheffield Scientific School of Yale University in 1931 and that same year went to work for Lupher Drilling Company in Michigan. Subsequent oil field activities have been with Pure Oil Company. He was in charge of drilling the discovery wells that opened the new Illinois fields in 1937, and was first division manager of Pure's Illinois Producing Division.

He was manager of the Texas and Rocky Mountain Producing Divisions before being moved into Chicago in April, 1947, as assistant vice president for production, and in October, 1953, was elected vice president for production operations.

API Fosters Schooling of Personnel

Reports of Committees on Training at annual convention will show most substantial gain yet made in attendance at courses and use of educational kits.

IN Long Beach a production superintendent goes to City College to learn how to lead a conference.

At Baytown, Texas, a pipe line engineer from Iran takes notes on a lecture on mainline maintenance.

On the East Coast a refinery safety engineer calls a group together and pulls out a kit on fire protection for study.

These and scores of incidents like them occurred during 1956 because the American Petroleum Institute fosters a cooperative educational program probably unique in scale for United States business and industry.

Going on the theory that the more you know the better you can do your job, committees on training in each major division of the Institute have worked out plans designed to give employees vocational training so important in a technical industry. More recently supervisory instruction has been added.

You may be one of the 75,000 persons since 1933 who has taken a vocational training course set up in the Division of Production.

Or you may be a supervisor who is considering a human relations course to learn how to work better with others in your group.

Or you may be in top management and need to study and evaluate the usefulness of the API courses for your own company personnel.

Whoever you are the API training courses command attention.

First, let us see how the courses are developed.

As in all its efforts, the API works

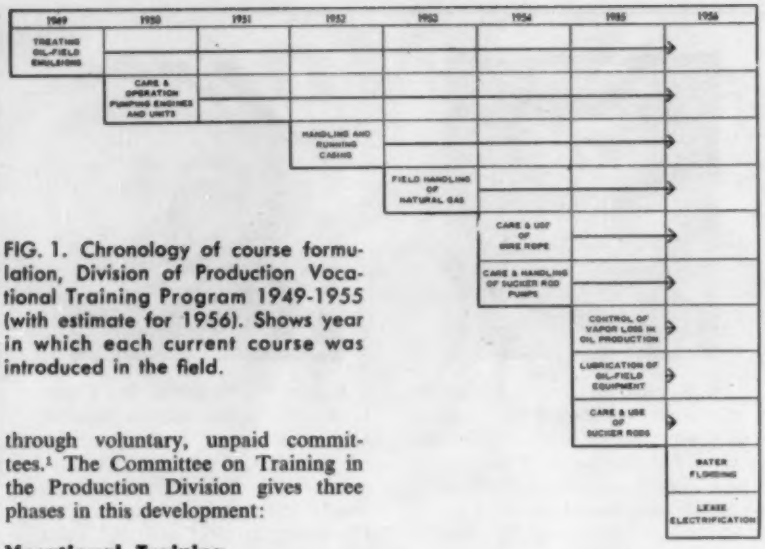


FIG. 1. Chronology of course formulation, Division of Production Vocational Training Program 1949-1955 (with estimate for 1956). Shows year in which each current course was introduced in the field.

through voluntary, unpaid committees.[1] The Committee on Training in the Production Division gives three phases in this development:

Vocational Training

1. **Formulation.** "In the first step—conception of a new course — committeemen throughout the country and others are given full opportunity to evaluate the need of the industry for instruction on any given subject . . . .

"When a course is authorized a special national subcommittee of industry specialists is appointed to determine in detail the information to be included in the course. At about midway in this task a formulating agency, usually the Division of Extension of a State University, is retained on an API grant-in-aid made up from API special funds. This agency works under the close supervision of the API subcommittee to draft the manual for the course and to prepare the necessary visual aids including motion pictures, charts, mock-ups, cutaways, and pilot plants.

2. **Promotion.** "The promotional phase, insofar as the API is concerned, is . . . carried out through mailing of printed material, press releases, notices in API publications, and arrangements for feature articles in trade journals. API Chapters play an important part in determining local demand for each course and at times organize and underwrite classes.

3. **Organization and Teaching.** "The teaching phase of the program is beyond the scope of the API and rests entirely upon the efforts applied by state vocational agencies and those companies which prefer to incorporate the course material in an intra rather than an intercompany effort.

"In the ideal case, a well-trained instructor is assigned by each major producing state in full time teaching duties on each new course from the time the course is first available until the saturation point is reached. This instructor, supplied with a panel truck or trailer for the equipment, moves from one production center to another teaching night or day classes, or both, while one or more other employees of the state are communicating with district and field supervisors to ascertain demand and block out future classes, each of which may contain employees of from 1 to 20 different companies."[2]

Fig. 1 shows in graph form when the vocational courses given in 1956 were formulated.

[1] 100,000 Committeemen Can't Be Wrong, by Ernestine Adams, November, 1954. *The Petroleum Engineer*. Page A-51.

[2] Personnel Development, paper written February, 1956.

These courses, which vary in length, are given in areas where the group is working.

Another more extensive type course is given at resident schools. The School of Production Technology has been available two years at Kilgore (Texas) College. This is a seven-week program and the enrollees sometimes come from long distances.

At the first School of Pipe Line Technology at Lee College, for instance, there are students from Iran and Iraq. This six-week school has more than the usual number of participating institutions. It is sponsored by API Division of Transportation, operated by the University of Texas' Petroleum Extension Service, cooperating with Lee College, Baytown, Texas, and Texas Education Agency's Trade and Industrial Service.

It should be added that some top industry pipe line men are instructors.

The course given October 8 to November 16, was limited to 30 persons and soon had many more applicants than that. Plans are for a similar course to be scheduled soon.

The Committee on Training of the Production Division has the most extensive program. Fig. 2 shows the cumulative number who have taken these courses. The figures do not include intracompany classes taught by company employees where API material is used. Some persons also use the manuals and literature individually for self-improvement.

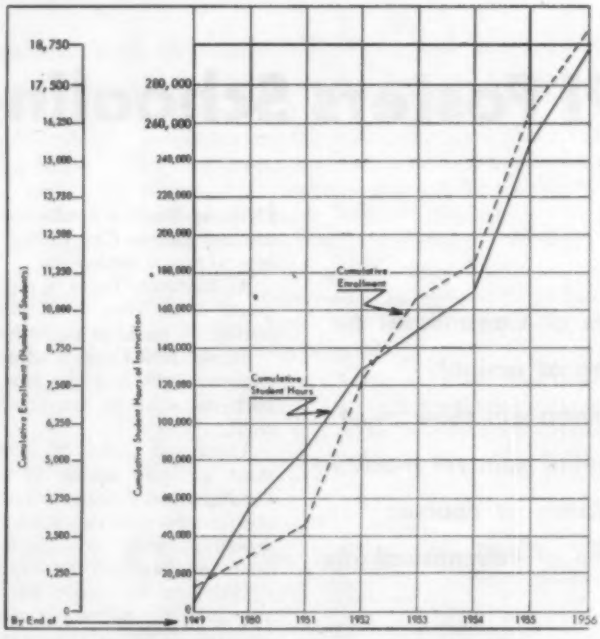


FIG. 2 Industry utilization of Division of Production Vocational Training Courses 1949 through 1956

R. L. Carruthers

R. L. Carruthers, Chairman, API Committee on Personnel Training, Division of Transportation, is supervisor of safety and training in the Personnel and Industrial Relations Department of Shell Pipe Line Corporation, Houston, Texas. He received a BS degree from Abilene Christian College, Abilene, Texas.

For six years he was athletic director and coach at high schools in West Texas, prior to joining Shell in 1942. His first job was as a laborer at McCamey. He soon became a first aid instructor for the West Texas area. From 1944 to 1947 he was a safety engineer for the Mid-Continent area with headquarters at Cushing, Oklahoma. He was made a training representative for the Mid-Continent area in 1947 and held that post until promoted to his present position in 1950.

John J. Stadtherr

John J. Stadtherr, Training Director of the API Refining Division, has been training director of Pure Oil Company, Refining Division, since 1949. He has been with that company since 1937 and prior to his present position was at the Heath, Ohio, refining variously as resident chemist, assistant general operating foreman, and training supervisor.

Stadtherr was graduated from the University of Missouri with a BS degree in education and major in chemistry, and did post graduate work in chemical engineering at Ohio State University.

From 1927 to 1937 he was analytical chemist and assistant resident chemist for Sinclair Refining Company at Coffeyville, Kansas.

His activities in organization work have been and are numerous.

Supervisory Development

Since 1952 a new program has been offered—supervisory training courses. Frank H. Willibrand said in his paper on the subject,[2] "A supervisory development program may be broken down into four major areas: (1) Training in new and evolving technology, (2) training in company methods and procedure, (3) education in basic economic concepts, and (4) training in human relations."

He felt that stress should be laid on the last mentioned: "It may be that adequate training in human relations will make effective training in technology, economics, or in company methods and procedure easier to accomplish."

Mr. Willibrand also emphasized the need for active support of the entire hierarchy of management for any supervisory program planned and organized to train those who direct the work of others. Otherwise he believed it was doomed to failure.

In one supervisory training course offered in cooperation with Public School Systems, Los Angeles Basin, the five classes included: (1) Conference Leading Techniques, (2) Problems in Labor Management, (3) Development of Labor Law, (4) Basic Principles of Economics and (5) Elements of Supervision.

Committees on Training

The responsible, industry-minded committeemen who do the work of developing courses are the real heroes of

[2] Supervisory Development, by Frank H. Willibrand, 32nd Annual Meeting, API, Division of Production, Chicago, Illinois, November 10-13, 1952.

Distinguished Program Set for API's 36th Annual Meeting

TOPFLIGHT representatives of business, industry, government, and education have been scheduled for the program of the 36th annual meeting of the American Petroleum Institute.

Between 6000 and 7000 persons are expected to register in Chicago, November 12 and 15. As in the past, the Conrad Hilton and the Palmer House will be the principal hotels for all sessions.

Principal speakers at the two general sessions on Wednesday and Thursday (November 14 and 15) include Secretary of the Interior Frederick A Seaton, API President Frank M. Porter, International Business Machines President Thomas J. Watson, Jr., and Frank O. Prior, president of Standard Oil Company (Indiana).

A "Gold Medal for Distinguished Achievement," which the Institute awards to some outstanding individual who has contributed much to humanity through the petroleum industry, also will be presented again this year. No award was made last year. The identity of this year's recipient will be announced prior to the Chicago meeting.

Among the many prominent executives of business, industry, and government who will address sessions during the four-day meeting are L. F. McCollum, president of Continental Oil Company, Houston; John G. McLean, vice president of Continental Oil Company, Houston; Commissioner Howard G. Freas, of the Interstate Commerce Commission, Washington, D. C.; George P. Baker, president of the Transportation Association of America, Washington, D. C.; Governor John F. Simms, of New Mexico, chairman of the Interstate Oil Compact Commission; and Richard Rollins, of Atlantic Refining Company, Philadelphia, 1956 national chairman of the Oil Industry Information Committee—petroleum's public-relations program.

Jake L. Hamon, of Dallas, chairman of the API Board, will preside at the two general sessions Wednesday and Thursday. He also will preside at the board meeting Tuesday morning and afternoon, and Wednesday afternoon.

One of the special features of this year's meeting will be a full-scale symposium on long-range weather forecasting.

Upwards of 150 or more committee and subcommittee sessions will be held during the course of the meeting. Some of these will get underway in advance of the formal sessions, and a few will continue through Friday, November 16.

this program. Their achievement in setting up this network of training helps has proved a valuable service to the petroleum industry. The class kits are available to any company in the industry.

F. H. Willibrand, Sohio Petroleum Company, Oklahoma City, whose paper was quoted above, is the chairman of the Central Committee on Training, Division of Production. Under him are R. E. Foss, Sunray Mid-Continent Oil Company, chairman of the committee on Vocational Training, and R. W. McIlvain, Jr., The Pure Oil Company, Chicago, chairman of the Committee on Supervisory Development. J. Forrest Smith, API staff at Dallas, Texas, handles administrative work in connection with all production training activites.

Foss and McIlvain have six district committeemen, each serving in designated areas.

In all there are 329 persons working on all the committees.

R. L. Carruthers, Shell Pipe Line Company, Houston, Texas, heads the Committee on Training for the Transportation Division.

Special sub-committees are sometimes appointed for special jobs, like the one of developing the pipe line technology course. R. A. Brannon, Humble; Morgan Martin, Gulf; R. W. Oldrich, Texaco, and R. L. Carruthers worked on this with the University of Texas staff.

James E. Moss, Washington, D. C., is API staff administrator for transportation.

Chairman of the Committee on Training, Division of Refining, is J. J. Stadtherr, The Pure Oil Company, Chicago. The officers, in addition to Chairman Stadtherr, are: M. L. Mullins, Standard Oil Company (Indiana), Chicago, vice chairman; E. R. Laminack, Socony Mobil Oil Company, New York, district committees chairman for programming; and Dean S. Turner, Standard Oil Company (Ohio), Cleveland, district committees chairman for membership. Administrator is W. T. Gunn, API, New York.

Work in the refining training program has not included courses but some of the projects will indicate the direction of this committee's efforts: Training Literature, Pump Manuals, Educational Exhibits, Manpower, New Projects, and the latest one, helping to prepare a new edition of "Glossary of Terms Used in Petroleum Refining."

Each project is in the hands of a subcommittee.

The Future

This is a bare outline of the present API organization for training. Its steady growth indicates the procedures fit into many company training programs.

The committees hold local, district, and national meetings to discuss and crystallize their ideas for future improvement in training programs. That the purpose and plans of these committees are set in the future is evident from the statement of the Committee on Training in Refining, which although it does not conduct classes, undertakes:

"A. To make significant information concerning existing practices, techniques, problems, and trends in the field of employee training available to the refining industry and to others through the publication of:

"1. The results of pertinent studies and surveys.

"2. Papers describing specific training programs, training techniques and procedures, and the sources and nature of training aids and services available to the industry.

"3. Reports of industry-wide training problems and training needs.

"B. To sponsor forums for the discussion of training programs, procedures, techniques, and problems.

"C. To sponsor:

"1. Certain practical research in the field of employee training.

"2. The development of certain basic training materials needed by the industry.

"D. To provide necessary liaison in regard to employee training in refining between individual segments of the refining industry, between the refining industry and its suppliers, and between the industry and educational agencies."

API Gold Medal Goes to Frank Drake

J. Frank Drake, former president and retired chairman of the board of Gulf Oil Corporation, Pittsburgh, Pennsylvania, has been named the 1956 recipient of the American Petroleum Institute's Gold Medal for Distinguished Achievement. Regarded as one of the nation's top industrial citations, the Gold Medal will be given to Drake next month at the Institute's thirty-sixth annual meeting in Chicago.

Formal presentation will be made November 14 by Jake L. Hamon, chairman of the API Board of Directors.

In receiving the API Gold Medal, Drake joins the ranks of such distinguished men of industry and science as Wallace E. Pratt, internationally-famed geologist and author, and former vice president of Standard Oil Company (New Jersey); Otto D. Donnell, former president of the Ohio Oil Company; Lieut. Gen. Ernest O. Thompson, veteran conservationist and former chairman and long-time member of the Texas Railroad Commission; Walter C. Teagle, former president of Standard Oil Company (New Jersey); J. Howard Pew, former president of Sun Oil Company; Dr. Charles F. Kettering, internationally-known scientist and inventor; and the late Henry Ford, the motor magnate.

Drake retired in April, 1955, as chairman of Gulf's Executive Committee, after having served five years as chairman of the board of directors, and 17 years as president. He is still a member of the Gulf board, however, and of its Finance Committee.

Frank Drake

Drake first joined Gulf in 1919, as assistant to the president. In 1923, he left Gulf to become president of the Standard Steel Car Company, another Mellon company. When Standard Steel and its subsidiaries were merged with the Pullman Companies in 1930, Drake was elected chairman of the board of Pullman, Inc. In 1931, he resigned to return to Gulf as president.

Drake was elected chairman of the board of Gulf in May, 1948, and five years later was named chairman of the Executive Committee.

A native New Englander, he is a graduate of Dartmouth College, where he received an honorary degree of Doctor of Laws in 1952. During his long career in petroleum, Drake has been a member of the board of the American Petroleum Institute, and has served with the Petroleum Industry War Council, and the National Petroleum Council, as well as the National Industrial Conference Board, of which he was chairman from 1945 to 1947.

Casa Presidencial in Guatemala City.

President and Mrs. Carlos Castillo Armas.

Three Stories of

GUATEMALA

Ernestine Adams

THIS is the story of three events — all so diverse and yet so tightly joined that you can't have one without the others.

It is the story of a nation drowning in communism, carrying its citizens deep into poverty and chaos and terror, then rescued in the eleventh hour by a young Lochinvar turned revolutionist.

It is the story of how one industry — the international oil industry — was squeezed from the scene by restrictions as powerful as the pincers used on human victims, then returned under a new economic freedom that will benefit the nation and, with luck, will in time benefit the industry and the hemisphere.

These are essential meat and potato events and the third story is only flowers on the table — a visit of oil women from all over the United States who flew in, then toured the nation in busses, took a thousand pictures, shopped in native markets, picked up Spanish and Indian phrases, loved the country, and praised the people — in fact, were diplomats of a pleasant and undemanding order.

All three of these events are really one — the story of Guatemala, our beautiful sister republic in Central America.

First Story

Two and a half years ago the grand Palace Hotel in Guatemala City for several weeks had only four guests knocking around its 110 rooms. Tourists shunned the shining city and many citizens who had displeased the government were in hiding or had fled their country. Fear was the only shopper and it bought the hearts of men.

Miss Adams is management editor.

Windows were boarded up in the stores on Sixth Avenue; building was at a standstill. The notorious chief of police Jaime Rosenberg made swift, secret arrests. Hundreds of political prisoners were taken. Some survived the dread tortures in Guatemalan cellars but were left crippled. Many died.

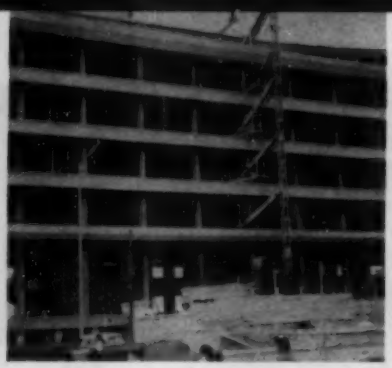
Today the windows are open, merchandise is plentiful, and carpenters work on new buildings that can be seen from almost any street corner in Guatemala City. Construction crews work on the highways stretching from the capital and circling picturesque mountains to join colorful interior cities.

Two and a half years ago the communists were in control. They had taken almost 10 years to grasp complete power. Forced to go slow at first, at the end their machinations were in full advance. They looted the treasury and had millions in unpaid bills. Government workers and teachers had not been paid in months. Business men with any money beyond actual needs smuggled it out of the blighted land. One estimate was that $100,000,000 had been sent to safer countries. Foreign investments were seized so no more came in. Economic development simply evaporated. Trade slowed to the exchange for bare necessities.

Much-heralded land reforms of the communist regime meant in the end that the government took land from owners, retained all titles, and rented small tracts to those who joined the communist-led peasants' union. Terror in the countryside had come even before terror in the city. Roving bands took

PHOTOS USED HERE ARE THROUGH COURTESY OF GLORIA CARVANTES, IRMA CLINE, SYBIL SURECK, DOROTHY SPRING, LEE WOOD, DOROTHY PRIMM, SCOTT WILSON & ASSOCIATES.

Palace Hotel is now busy place.



New city hall goes up in Guatemala City.

Site of planned Hilton Hotel.

land distribution into their own hands, burning and pillaging the countryside. There was enough government land for everyone who wanted it but the Red-inspired peasantry seized farms from rightful owners.

In June, 1954, Colonel Carlos Castillo Armas, young soldier turned revolutionist, led his small force from Honduras where he had worked for two years building an anti-communist force. He ousted President Jacobo Arbenz Guzman, who had taken the Reds in and who expected, with communist aid, to become dictator. Castillo Armas freed the anti-communists, and filled the prisons with suspected Reds until each case was decided in the courts. The top men in the oppressive administration scampered to safety in the Latin-American embassies. At one time 400 filled the small halls of the Mexican embassy; more than a hundred were in the Salvadoran embassy, and lesser numbers in a half dozen others.

There seldom has been so vivid an example of the decadency of communism. The evils of the military dictatorship of Ubico look almost sane beside the excesses and fanaticism of the internationalist movement. Guatemala's Reds had no interest in Guatemala and Guatemalans except to further the cause of world communism through the country and its people. We'd have to go back to the Spanish conquest of the Mayan Indian Empire to find a comparison with the ruthlessness and sadism of Guatemala's last year under communist rule.

Politically and economically, the garden nation of Central America has done an about-face. From the time he took over his office, President Castillo Armas set his country's course boldly, employing a combination individual and government enterprise system much like that of the United States.

The reward has been astonishing economic progress. It isn't only that tourists are coming back, trade has opened up and capital investment feels safe again. Basic changes are forming that will bring greater abundance to a rich, awakening country.

We always come back to the petroleum industry for economic measurements. It would be hard to find a better gage for modern progress. So how does Guatemala score here?

Consumption is the basic standard, of course. Rodrigo Cordova Cerna, Director of Mines and Hydrocarbons, states that consumption of gasoline and gas oils in 1955 was 50 per cent above the previous year. This year will see another steep climb in consumption to bolster and to record the rising standard of living.

Second Story

Progress is measured also by how natural resources are handled. Castillo Armas has made drastic changes here.

For many years geologists have believed there was oil in Guatemala but little effort has been made to find it. The nation had no oil industry to explore and develop the resource. Conditions under which foreigners could gain concessions were so restrictive that companies like Sohio, Shell, Jersey, Atlantic, and Ohio gave up trying to explore.

When President Castillo Armas took over the reins, he approached the petroleum situation as he did other business and resource problems . . . called in expert legal and technical consultants to help write laws so the nation could profit fully from outside capital invested in petroleum exploration and development and at terms fair to risk capital.

Under the law, an oil company can obtain up to 400,000 hectares* (approximately 1,000,000 acres) for exploration and hold on to them as long as 10 years. A payment of $500 is required with each application.

Some obligations are: To begin their exploration work within 90 days following the effective date of the right‡ and continue it with due diligence during all of the time in which the exploration rights are in effect. In the first 3 years at least quetzale† 0.90 a hectare must be spent on the concession, the second 3 years Q1.05 a hectare, and in the remaining 4 years Q0.40 a hectare.

Surface taxes on exploration rights range from Q0.30 in the first 3 years to Q0.60 in the seventh and subsequent years of exploration.

Should oil be found or exploitation rights be granted, the holder must return 50 per cent of the area in his concession to the government and exploitation rights are given on the 50 per cent he elects to keep.

A well must be spudded in within 6 months of the exploitation right being granted. Surface taxes during exploitation range from Q1.50 a hectare in the first 5 years to Q4.50 in the 16th year on up to 40 years. Royalty paid is deductible from these taxes.

*One hectare equals 2.47 acres.
‡"Right" is the term used for Guatemalan concessions.
†A quetzale (Q) has the same value as a dollar.

Edna Hurry, president of Desk and Derrick, receives flags from President Castillo Armas.

Desk and Derrick tourists traveled in special-chartered busses carrying flags of Guatemala.

Edith Snizek, Irma Cline, D & D president-elect, and Eleuise Norris, in flower-filled patio.

Royalties going to the government of Guatemala begin at 12.5 per cent of oil produced, and there is the added stipulation that the sum going to the government of Guatemala for royalties, taxes, etc., cannot amount to more than 50 per cent of the net profit of the oil company.

No import duties will be levied on oil equipment needed in operations. Export or other taxes will not be levied on crude oil, its production or handling. The government retains the right to prohibit the export of crude up to what may be required to meet home consumption, although there is no obligation upon an operator to refine locally.

The companies also are required by law to hire Guatemalan labor to work as employees in all of the branches of the petroleum organizations, in equal conditions and salaries with the foreign employees of the same category, provided they are equal in competence.

In addition, the law points out that if the competence of the Guatemalans and that of the foreigners are the same, the Guatemalans shall be preferred until 80 per cent of the total of the persons employed by the petroleum organization are covered.

Petroleum companies are also to have "apprentice programs" and other educational projects to train Guatemalans in the more advanced positions connected with oil operations.

This is a law the international oil industry can work with although we should like to insert parenthetically that no one has ever told the full story of the blood and sweat and money that must be poured into jungle operations before even the possibility of profit appears.

Applications by speculators and non-operators were eliminated in the financial and technical standards set up by the Guatemalan government until 29 companies and individuals* remained eligible for concessions. Applications overlapped on all except two. Signal Exploration Company (Signal Oil & Gas Company, California) got the first concession of 673,000 acres in South Peten. A concession applied for by Story James Sloane of Houston, Texas, was cleared.

An operators' committee, embracing all companies, worked out agreements on overlapping areas and these presumably will be approved by the government, since the committee had official sanction. As a result of the operators' work a 650,000-acre concession was granted recently. Ohio Oil of Guatemala is operator and Standard Oil of California and Union Oil of California have minor interests.

Another grant was made to Standard California and five other companies over a 67,000-acre concession near Puerto Barrios.

Sun holds a 593,000-acre concession in North Peten and Texaco has an adjacent 744,000-acre concession. These two will be operated by Texaco on this kind of split: Texaco, 44.98 per cent; Sun, 27.07 per cent; Tidewater, 22.53 per cent, and Atlantic, 5.42 per cent. Tidewater and Atlantic retained part of their original claims in the same area.

Petroleos Guatemaltecos S.A., a domestic firm, was granted a 58,500-acre concession also in North Peten, near the Mayan ruins of Tikal.

Continental Oil was granted petroleum rights on 394,000 acres in northern Guatemala, in the Flores area of the state of Peten. The acreage will be combined with that granted subsidiaries of The Ohio Oil Company and Amerada Petroleum Corporation to form one single unit. Preliminary exploration work already has been completed on the concession, and additional exploration operations will be started.

Kerco, Inc., of Denver has acquired petroleum rights on 750,000 acres in northeastern Guatemala. Preliminary exploration work has been done and a drilling program is tentatively set for early 1957. Other certifications are being made currently and most of Peten will be covered by rights.

Several U. S. companies have set up offices in Guatemala City and have a resident staff. Visitors are frequent from home offices.

Favored area for exploration is El Peten, a giant jungle-covered basin that thrusts up between Mexico and British Honduras like the head of an ax from the spreading highlands of South Guatemala. There are no highways in the area and no broad streams for navigation. Peten is the largest single department (state) in Guatemala. The second promising department is Izabal, south of Peten, which has Guatemala's major Atlantic seaports of Puerto Barrios and the new government-built Puerto Santo Tomas.

Offshore areas are covered by some applications. The Bay of Amatique, northwest of Puerto Barrios, and Izabal Lake have attracted oil men, which some compare with Venezuela's Maracaibo.

Claims for the area north of here, British Honduras, have been made in the United Nations by Guatemala. Gulf Oil has prospecting licenses covering all of British Honduras.

Oil companies will risk millions of dollars in Peten and

Ruins of ancient Mayan temple uncovered in Peten.

*These include: Guatemala Atlantic Corporation, Tidewater-Guatemala, Ltda., Sohio Caribbean Company, Petroleum Investment (Overseas) Ltd., The Ohio Oil Company of Guatemala, Amerada Petroleum Corporation of Guatemala, Inversiones Guatemaltecas Americanas S. A., Continental Oil Company of Guatemala, Sun Production Company, Seaboard Exploration Company, Esso Standard (Guatemala) Inc., Petroleos Guatemaltecos, S.A., Bandini Petroleum Company, Jaime Allan Willard Duran, Texas Petroleum Company, Union Oil Company of California, Compania Petrolera California, Signal Exploration Company, Story James Sloane, Central American Oil Mining Company, Antonio Molina Murillo, Petroleos Atlas de Guatemala S.A., Compania Petrolera Guatemalteca, S.A., and Kerco, Inc., of Denver.

Hotel on Lake Atitlan. Guatemalan gardens are luxuriant.

Guatemalan children play on road high above Lake Atitlan.

Izabal because of their faith in a few geologists and their hope of making a profit.

This purpose satisfies almost everybody except the communists and socialists.

David Graham says in *The Nation* (July 14, 1956) that the old petroleum law (drawn up by an Argentinian) was "all right with the Arevalo-Arbenz (communist-run) crowd; they preferred to let the stuff stay in the ground rather than have it pumped out at a fat profit to foreigners."

That is what happened to Guatemala under the communist rule. Not only did oil stay in the ground but economic progress went underground. The leaders fared well, another phenomenon of communist government. Arbenz himself is said to have accumulated $5,000,000 before he fled to Mexico and moved later to Prague, Czechoslovakia, where he is probably useful in the notorious school for infiltrators, agitators, and saboteurs. Others in his cabinet also turned political power into large personal fortunes.

President Castillo Armas found a floating debt of $7,500,000 registered when he took over and unregistered claims which ran debts to nearly $30,000,000. The debt has been reduced and bills are being paid. Industry and commerce are getting back on their feet. The U. S. embassy reported in August, 1956, that coffee exports — the leading export — brought $67,000,000 in the first half of 1956 and the corn crop (consumed domestically) was better than the year before. Two firms — one U. S. and one Guatemalan — were granted 20-year concessions to exploit lumber in Peten. Aside from payment, obligations were to reforest, to build roads, and to export wood in boards. A new wood processing plant, backed by U. S. money, will go into operation shortly.

The International Railways bought 13 new diesel engines at the cost of $2,500,000. A soluble coffee plant is being constructed by Guatemalan, U. S. and Salvadoran interests. A new tire plant is being built to use native rubber. A new Hilton hotel is planned. A plywood plant will be built by U. S. and Guatemalan operators. The country's only cement company is getting underway. United Fruit, which was used as a whipping boy for "Yankee imperialism" by the communists, is spending $2,000,000 in capital replacements and expansion.

The second television station has been opened.

The energetic Lic. Salvadore Saravia, Minister of Economics and Labor, is promoting installation of a refinery in Guatemala. So far Story J. Sloane and Embry Kaye, Tulsa, Oklahoma, have applied for permits to set up plants.

The blight of communism has not disappeared. A thousand or more fled to neighboring countries, living to conspire another day. Some have doubtless remained to infiltrate the administration and the military.

There are occasional flareups. Paul P. Kennedy, *New York Times*, correspondent, says, "Many of these difficulties stem simply from the old truth that after any successful revolution nearly everybody wants as big a share of spoils as he can get. For example, Castillo has tried to balance the demands of businessmen who felt they had long been abused under Arbenz with those of labor leaders who feared any concessions would mean forced retreat."

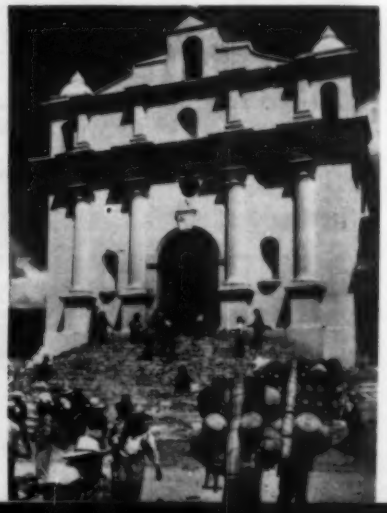
It will be many years before any foreigners make what Mr. Graham calls a "fat profit" from oil in Guatemala — if they ever get near oil. But results of oil activity can already be seen. Money from present leasing has been put immediately into roads, according to Castillo, and this with other highway funds gained through U. S. loans is keeping crews at work in many areas. In March the last section of the Pan-American highway will be ready; also the new highway link between Guatemala City and the Atlantic ports.

Office space and houses are scarce in Guatemala City. The influx of oil staffs helps support new building downtown and in the residential district. U. S. wives are good boosters for

Making sandals from old automobile tires.

Indians in rich-colored homespun clothes light incense on steps of famous Chichicastenango church (shown at right). Behind them are tents of the market place, set up in the town square during the night. Here are sold hand-loomed textiles, food, spices, candles, leather goods, pottery, cabinets, hand-wrought silver.

Church of Santo Tomas with worshippers on steps.



D & D group ready to board plane. Fourth from left is Mrs. Sybil Sureck, and sixth is Mrs. Nell Barclay, president and secretary last year.

the attractive hand woven textiles for which the Guatemalans are famous, for leather and silver products, for food and flower markets. They support the ambitious fashion market that has made a small but impressive start. Oil industry personnel are good community people and they are proving it once again in Guatemala.

Third Story

Because the petroleum industry has come back to Guatemala, the women who work in the industry were invited by the government* to visit the country after the annual Desk and Derrick Convention in New Orleans. (They were to pay their own way but the trip was sponsored by the government.) Sixty-five oil women from all over the U. S. flew to Guatemala on the TACA International Airlines landing at Guatemala City. They were met by Dr. Carlos Cifuentes Diaz, Secretary of Press, Culture and Tourists, and some assistants.

The welcoming party included pretty Guatemalan girls from local oil offices proudly wearing name tags that included familiar company names. Like oil people everywhere, each was looking especially for anyone from her own company.

President Castillo Armas and his lady were hosts at a reception at the Casa Presidencial the first evening, both of them chatting with each guest.

Back at the Palace Hotel, a surprise awaited the visitors. Oil people in Guatemala and local business leaders were invited to an evening of pleasure in honor of Desk and Derrick members. There was a style show, a buffet supper, a ballet, followed by dancing to a marimba band.

The lobby at the Palace, once haunted by silence and empty rooms, was a gay and sparkling place that night.

Early next morning busses, flying the president's flag, took the oil women into the interior. To lovely Antigua, first capital of the kingdom, whose ruins of magnificent buildings from the days of Spanish Colonial rule are softened and decorated with luxuriant flowers and shrubs. To sparkling, multicolored Lake Atitlan, high above sea level, surrounded by volcanic mountains on whose shoulders rest winding cloud stoles. To Chichicastenango, where on market day a city of tents rises in the square and religious ceremonies in the church of Santo Tomas fill the air with spicy incense.

They saw all these and more—Indian villages with people in colorful dress — for a person follows the costume of his village no matter where he goes. Indian children and grown-ups waving at the smiling women in the busses and sometimes clapping in good humored welcome.

If the sullenness of communism still lives, it is well concealed in dark hills, because the people were pleasant and amicable in the small settlements and in the big market places. They cheerfully tried their unique English and listened politely to unique Spanish. They are friendly with no touch of servility; there are few mendicants but many street sellers with enterprising sales promotions.

So these are the stories of Guatemala. They are a study in capsule form of today's world problems.

The problem of communism will find few better examples than the story of Guatemala. Arevalo's "spiritual socialism" was its breeding ground. It began on a high level, cleverly infiltrating the unions, the military, the schools. It ended by killing and torturing those suspected of disagreeing with its rule.

The economic problem all over the world is spelled out by the events in Guatemala. Industry and trade and development of resources cannot be successfully enslaved any more than people can. In this 20th century it is only a free people with room to move economically who can command a progressively higher standard of living.

The third story is only a very small incident in the problem of mutual good will among nations. The oil women were made genuinely welcome and they responded with appreciation and respect for the country and its people.

Today, business and trade, and especially our industry are international. It is well to remember that so is brotherhood.

★ ★ ★

*Through its public relations counsel in the U. S., Scott Wilson & Associates, New Orleans.

D & D group at Palace Hotel. Miss Hurry, club president, is fifth from left in first row. Scott Wilson of the public relations firm is at right, second row.

Resources of Mind and Material Are Combined in.....

J. C. Donnell, II
President
Ohio Oil Company

W. H. BARLOW
Manager,
Research Department

W. J. YOST
Research Director

J. E. WHITE
Supervisor,
Physics Section

L. C. GIBBONS
Supervisor,
Chemistry Section

F. H. POETTMANN
Supervisor,
Engineering Section

R. D. RUSSELL
Supervisor,
Geology Section

J. W. BRUSKOTTER
Supervisor,
Business Section

WHEN its management became convinced that scientific research was essential to its progress, The Ohio Oil Company set out to establish a center of its own. It is perhaps the smallest company in the industry to install a complete modern plant to be devoted to research in petroleum and to investigation of other energy sources.

The handsome research center at Denver, Colorado, is the result of a long interest in research possibilities.

Four years ago, the company's board of directors requested Battelle Memorial Institute to conduct a survey as a guide in determining its role in research. The Battelle report supported the view that the company should undertake research as a permanent part of its operations.

At the three-day dedication program, J. C. Donnell II, president, reviewed the steps followed in establishing a totally new department and physical plant for private industrial reasearch.

First, the research department was set up in the Findlay, Ohio, headquarters with W. H. Barlow as manager. He was given the assignment of supervising construction of the Center and organizing the new research department, which he accomplished in two years—a unique achievement. It was October when a director of research was found. Dr. W. J. Yost joined the department and then both men sought key scientists needed as a nucleus for a technical staff. They soon added L. C. Gibbons, chemistry section; F. H. Poettmann, engineering; R. D. Russell, geology, and J. E. White, physics section.

When the formal opening took place during Oil Progress Week, there were 46 employees, including 18 research technologists. Within the next two or three years, the total staff is expected to be increased to 115 of whom 75 will be research personnel.

Speaking of personnel, President Donnell said:

"We have adopted a policy for our scientific personnel in the research department of permitting them a certain amount of free time during which they may pursue investigations of their own choosing, and we fully anticipate that some of the best ideas will result from this one policy. We also intend to follow a liberal publication policy, and we will encourage our scientific personnel to participate in outside meetings, seminars, and conventions."

Laboratory Site

Another job was to find a site for the laboratory and service buildings that would be a good place to work. Denver, Colorado, was selected after careful study. There are no major petroleum research centers in the area and, at the same time, there are a number of institutions valuable to the researcher. Denver University, Colorado School of Mines, the University of Colorado, the U. S. Geological Survey, the Bureau of Reclamation, and the Bureau of Standards, all have staffs and facilities that make up an environment needed in research.

The universities in the area will probably supply many of the growing staff at the Research Center.

The actual location is south of Denver on an 80-acre property with an imposing view of the Rocky Mountains and of the city.

Buildings

The next step was to plan the buildings themselves. Barlow and two of the staff worked with the architects and the general contractors to design

Assembly room has theater-type seats, motion picture projection booth, etc.

..Ohio Oil Company's New Research Center in Denver, Colorado

The lobby is defined by free-form canopy and carpet.

The Ohio Oil Company's Research Center stands at the crest of a foothill commanding views of the Rockies and of Denver.

the structures for best possible use by the staff.

The main building has three wings: Administrative, service, and laboratory. It is a one-story spread, the walls faced with native sandstones. Total area is now 45,000 sq ft with a planned addition that will double the size of the laboratory wing and increase the total to 65,000 sq ft.

One of the features of the service wing is a cafeteria with glass walls on three sides where diners can enjoy a magnificent view of the Rocky Mountains stretching from Pikes Peak on the south to Longs Peak on the north.

In the east wing two rows of laboratories are separated by a utility corridor. These fill the center of the wing. A line of offices for the researchers run completely around the inside walls. An attractive and convenient assembly room, for 80 or more people, and a well designed library complete the laboratory wing.

Another building, similar in color and design, is the garage. This has space for parking company vehicles and undersurface storage areas for volatile materials and well cores.

Equipment

Only basic equipment has been installed. New pieces for special work will come out of the shops which have modern metal and wood working tools.

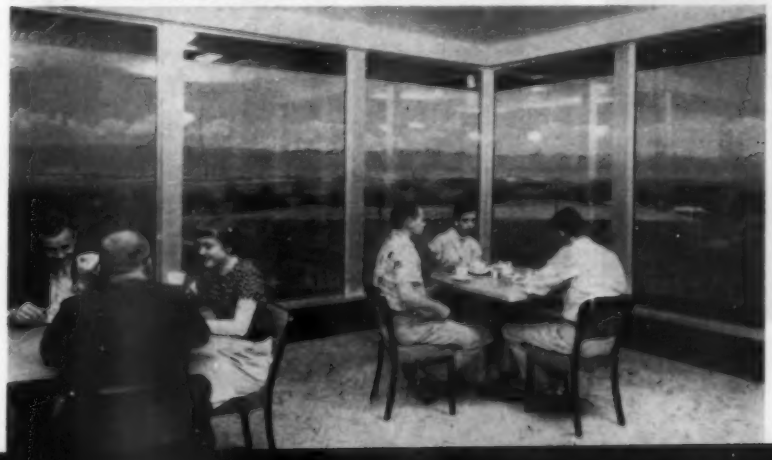
An electronic computor installation combines Electrodata and IBM equipment.

Research Objectives

President Donnell spelled out his company's research objectives at the Center's dedication.

There will be a concentration on methods of increasing recovery from reservoirs where present operations have low recoveries, on sharpening exploration tools to improve discovery performance, and on improving techniques and equipment in drilling and production operations.

Through walls of glass on three sides, diners in cafeteria enjoy mountain scene.



The research department will help keep operating technical personnel and management reliably informed on rapidly changing scientific and technical developments.

Said Ohio Oil's president:

"As for new fields of endeavor, the ones that come to mind immediately include the growing field of petrochemicals. In this connection the research staff has already begun to make contributions to our management. Furthermore, with the assistance of the research department the company can turn its attention to such fields as oil shales, tar sands, and the production of synthetic liquid hydrocarbons. Nor do we intend to neglect the investigation of energy from sources other than fossil fuels. The point I want to make is that we are entering research on a permanent basis with the full realization that much time will elapse before the benefits will accrue to the company to the extent anticipated."

Importance to Ohio Oil and to Denver of the new center was indicated by the three day dedication and open house. Members of the press had a preview Tuesday, October 16. At dedication ceremonies Wednesday, U. S. Senator Gordon Allott (Republican, Colorado) and Mr. Donnell made addresses to Ohio Oil personnel and guests. Thursday, Dr. W. V. Houston, president of Rice Institute, Houston, Texas, spoke before an audience of more than a hundred scientists and educators from all over the country. Friday, the Research Center was opened to public inspection. ★ ★ ★

What's the Best Way to Put Out a Fire?

Different kinds of blazes are handled various ways, people find at Southwestern Fire and Safety Clinic

FIG. 1. This 150-lb dry chemical wheeled fire killer is inspected at the first annual Southwestern Fire and Safety Clinic given at Tulsa, Oklahoma.

FIG. 2. Flaming gasoline spilling down this inclined board is attacked with a carbon dioxide portable. Seconds later the blaze was out. Carbon dioxide in addition to its fire killing ability cannot damage production machinery or work-in-process, is a non-conductor of electricity, and being an inert gas eventually is absorbed into the atmosphere following discharge, leaving no mess to clean up.

MORE than 150 persons attended the First Annual Southwestern Fire and Safety Clinic held at Tulsa, Oklahoma, in May. The show was presented primarily for oil company safety personnel from Texas, Kansas, and Oklahoma by the Allan Edwards Manufacturing Company, Inc. and Walter Kidde & Company, Inc. In addition, representatives from steel, insurance, and manufacturing companies, schools, fire departments and the Air Force also were present.

During the day-long session, more than 30 fires of types frequently encountered in industrial plants, refineries and the oil fields were lit and then extinguished by appropriate portable equipment. The one in Fig. 3, for instance, was extinguished with a 15-lb carbon dioxide portable and later with a 20-lb dry chemical portable (shown at left). These included wood, flammable liquid, and electrical fires. Among the extinguishing agents demonstrated were water, dry chemical, carbon dioxide, and foam.

FIG. 3. Perforations in the elevated hoop sprayed gasoline which ran down the pipe line. When set ablaze in a brisk wind, this fire resulted.

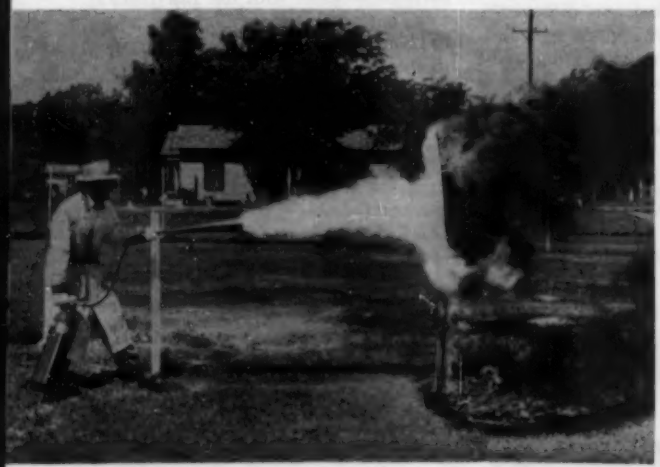
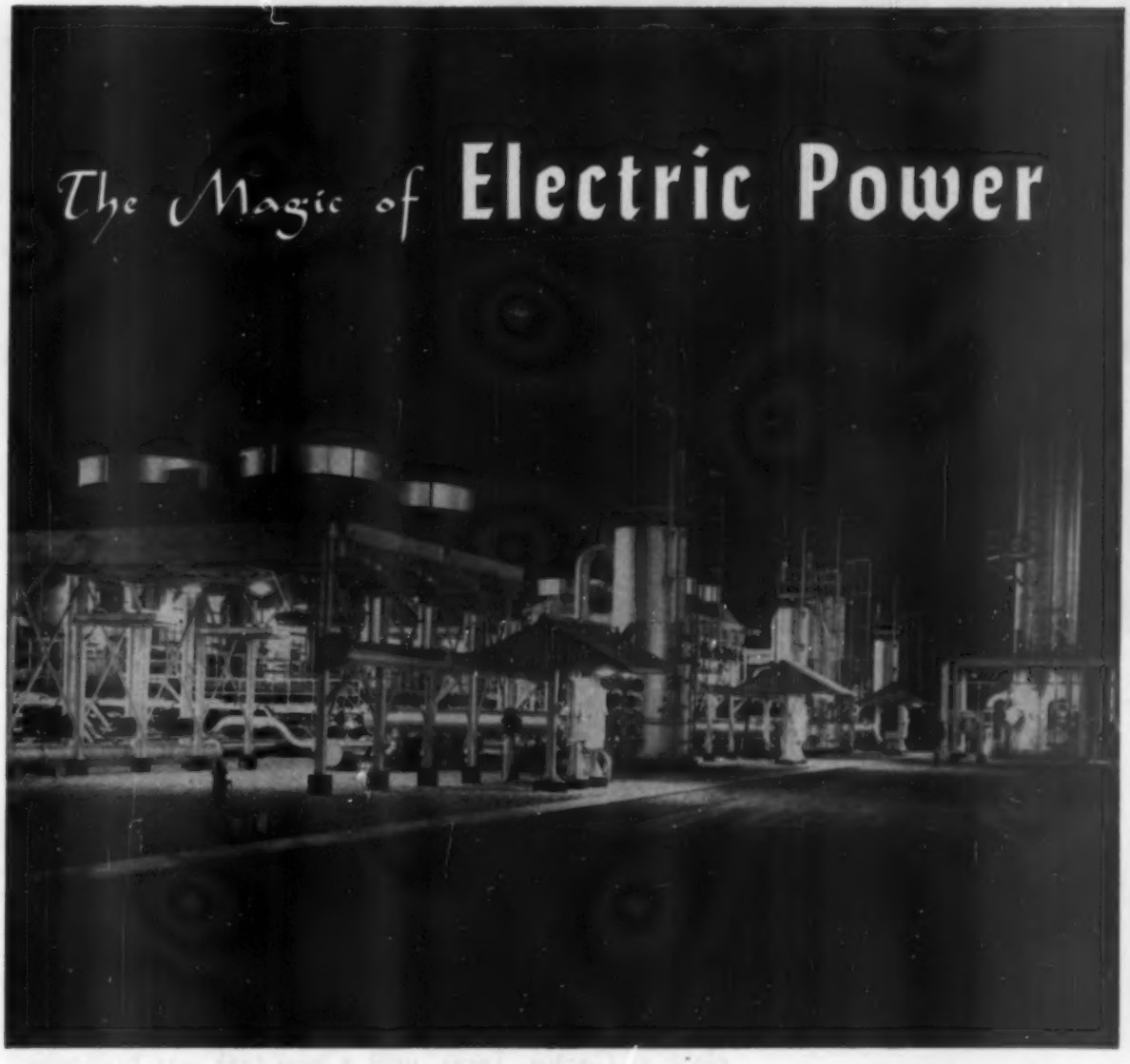


FIG. 4. Burning gasoline spilling down the sides of this tank was extinguished with a 30-lb dry chemical portable.



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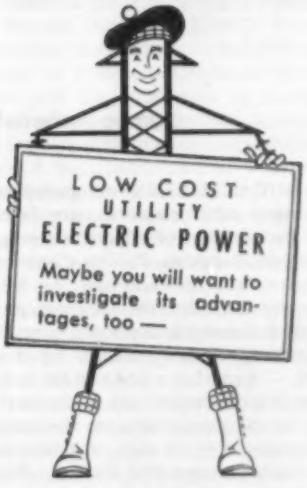

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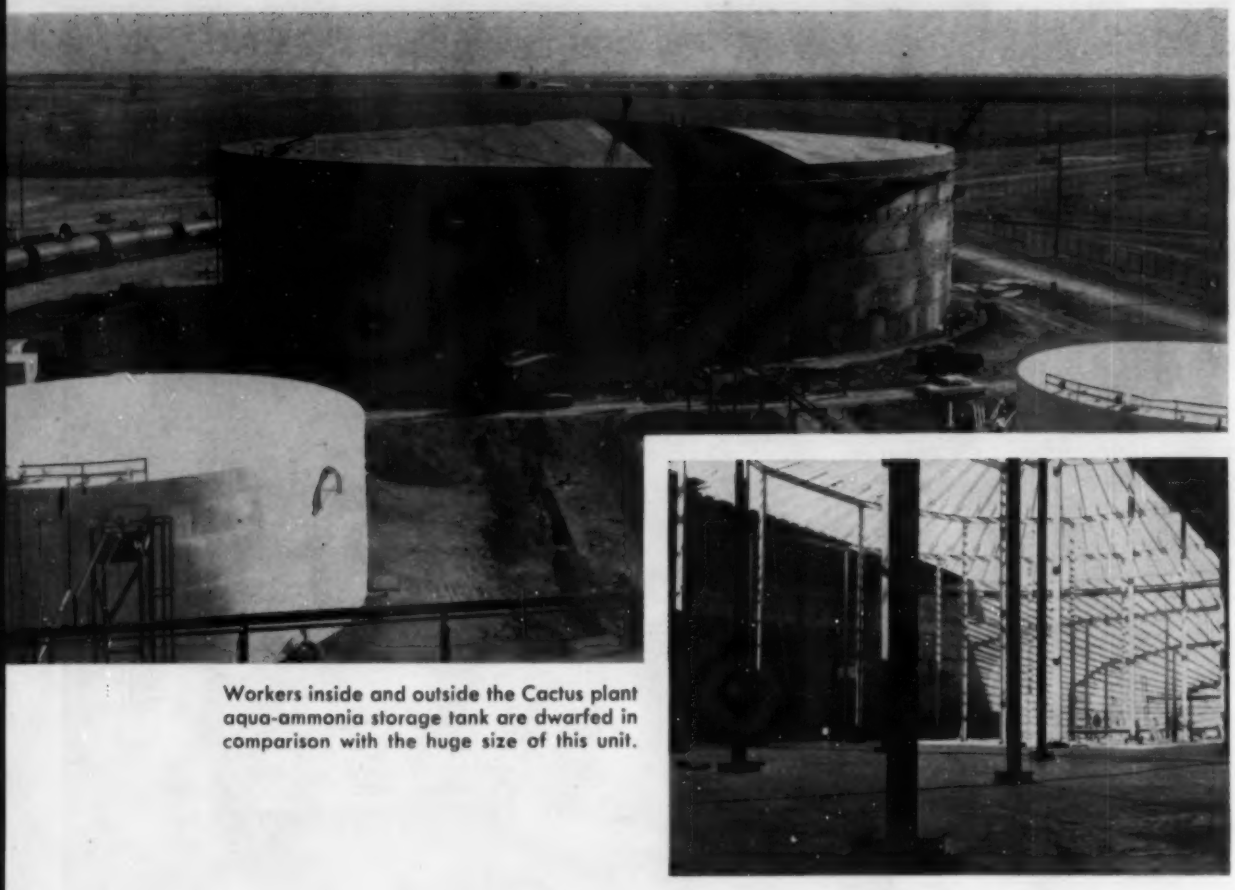


Workers inside and outside the Cactus plant aqua-ammonia storage tank are dwarfed in comparison with the huge size of this unit.

BIGGEST in the Business

Storing ammonia was a problem at the Phillips Chemical plant at Cactus, Texas, until a new tank was built which covered an acre and had a capacity of 323,000 bbl.

James Roberts*

MANUFACTURERS of ammonia, like many other concerns, are faced with the problem of adequate storage during slack seasons. Phillips Chemical Company was no exception. To help solve this difficulty, the idea was projected of dissolving ammonia in water and storing the low-pressure liquid in a tank — and what a tank! So far as we know, it is the largest tank in the world used for the storage of aqua ammonia.

Completed in 55 days, this new atmospheric pressure tank increases Phillips above and underground storage facilities for ammonia and aqua ammonia to almost 1,000,000 barrels. The huge tank, covering nearly an acre of ground, is 48 feet high and 220 feet in diameter. Capacity is 323,000 barrels.

Some 1,918,384 pounds of steel, plus 7839 pounds of welding rod, were used in construction work. On a comparative basis, if the steel in the average automobile weighed 4000 pounds, the steel used in this tank would be enough to build about 4795 cars.

Aqua ammonia is now being pumped into this tank at a rate of about 250 gallons a minute. At maximum pumping capacity, it is estimated that nearly 37 days will be required to completely fill the storage tank.

Seasonal demand for ammonia as a fertilizer is heaviest in the spring. Summer and winter storage of ammonia helps Phillips maintain plant production on even schedules and provides customers with adequate supplies when they are most needed.

When the tank is painted and the huge orange and black Phillips shield is in place, it should become a familiar landmark, greeting the motorists who pass Cactus, Texas, plant on nearby U. S. Highway 287. ★ ★ ★

*Phillips Chemical Company, Etter, Texas.
This feature was reprinted from the February, 1956 issue of *Philnews*, Phillips Petroleum Company's employee publication.

first of a series

This is one of a number of articles on management development training in universities and colleges. The growing need of instruction and idea exchange has given educational institutions an opportunity to aid business and industry in executive training.

Management Course Limited to 25 Persons

Oklahoma A & M Executive Development Course concentrated in three weeks . . . Industry lecturers aid in instruction and exchange of information.

Wilson J. Bentley

ON the Oklahoma A & M College campus at Stillwater, middle-to-top management people enroll in the Executive Development Course for 3 weeks, spend some 125 hr increasing their skills in managing.

They receive concentrated instruction in the fields of: Management fundamentals, oral communication, human relations, economic analysis of alternatives, improvement of work methods, motivation of people, and related subjects. Time is also arranged for consultations on individual industrial problems.

The course, in its fourth season, is sponsored by the School of Industrial Engineering and Management in co-operation with the Division of Engineering and Industrial Extension. It is attended by people from various sections of the United States as well as from foreign countries.

Some have come from Venezuela and Canada; others from the states of Indiana, Wyoming, Montana, Missouri, Texas, Colorado, Kansas, Oklahoma.

Designed primarily for people in middle management, the group from which many leaders at the topmost levels are chosen, the course is the outgrowth of nearly 20 years of experience in management instruction.

Professors P. G. Thuesen and Wilson J. Bentley are the co-heads of the course. Dean M. R. (Pete) Lohmann, dean of the Oklahoma Institute of Technology, takes a key part in the core subject of management. All three are well known educators and industry consultants. Their philosophy in relation to their course is summarized by the following description:

> The successful executive is the one who is able first to establish high but attainable goals and then motivate and direct individuals and groups of individuals to action which will achieve these goals. His primary function is getting results through the direction of other people. For this reason major emphasis in the program is given to management defined as the "activity of stimulating people to accomplish desired ends through cooperative human effort." The course is designed to help develop and integrate a framework of ideas, concepts and principles to guide the executive in making sound decisions and taking sound action in both immediate and long-range situations.

An important feature of this course is that it is limited in size. The sponsors believe that 25 students should be the maximum enrollment. This results in maximum participation on the part of the students, as well as, individual advisement on the part of the instructor. The number from any one company is also limited in order to provide the best exchange of information.

In addition to members of the Oklahoma A & M College faculty, lecturers have been A. R. Bell, Jr., controller of General Crude Oil Company, Houston, Texas; Francis J. Curtis, vice president of Monsanto Chemical Company, St. Louis, Missouri; J. O. Grantham, employee relations manager, research and development department, Phillips Petroleum Company, Bartlesville, Oklahoma; Dr. S. I. Hayakawa, semantics authority and professor of English at San Francisco State College; Professor John F. Mee, chairman of the department of management, Indiana University; Dr. Ralph Nichols, professor of rhetoric, University of Minnesota; James C. Phelps, director of development and technical advisor, Continental Pipe Line Company, Ponca City, Oklahoma; and Gilbert V. Rohleder, director of the Okan Pipeline Company, Tulsa, Oklahoma.

In this program organized knowledge, principally in lecture form, is presented as an integrated framework of ideas, concepts, and principles. The lectures are followed immediately by group discussions which give the learner immediate opportunity to apply his newly acquired ideas, and try them out in practical situations.

Frequent opportunities are given to express ideas orally, before the group. Less frequently, the participant will be asked to give written expression to certain of his ideas.

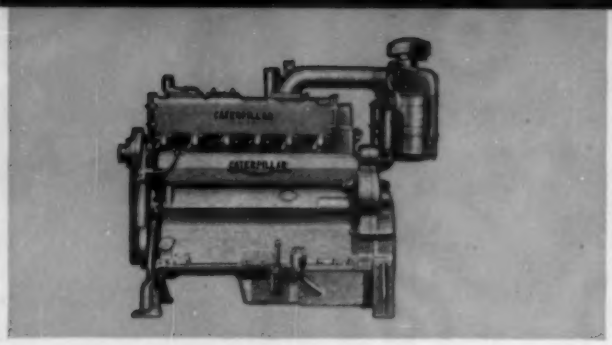
Date for the next course is February 4 through February 22, 1957. Persons attending the conference should be prepared to present problems for discussion and for application of management concepts of principles developed in the program. In most cases problems should be summarized in writing to facilitate presentation to the group.

There are 5 days of formal instruction each week with 5¾ hr of formal instruction scheduled between 8:45 a.m. and 5 p.m.

Accommodations are available on the campus in the well appointed Union Club, which is a part of the Student Union Building.

Tuition for the course is $360 and includes all required instructional materials. Registration is made by addressing the Division of Engineering and Industrial Extension, Oklahoma Institute of Technology, Oklahoma A & M College, Stillwater. ★ ★ ★

Professor Bentley is with the School of Industrial Engineering and Management, Oklahoma Institute of Technology of the Oklahoma A & M College, Stillwater, Oklahoma.



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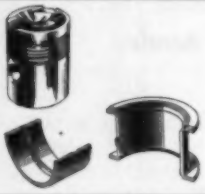

A quarter of a century ago, Caterpillar created mobile diesel power. For the first time, the power of the diesel engine was unleashed from its bulky foundations and put to work in the field—compact, economical. Here was diesel power of simple design, with no need for experts to operate and maintain. Here was diesel power with the lugging ability to knuckle down to the tough jobs.

The introduction of mobile diesel power was a tremendous advance in many fields. It provided efficient diesel power for tractors, motor graders, earthmoving equipment . . . for the work boat, the gin, the locomotive, the oil rig, the municipal plant . . . for *any* application in which steady, low-cost power is crucial. And everywhere, CAT* Diesel Engines proved themselves durable and dependable. They established Caterpillar as the leader in diesel engineering.

Today, hundreds of thousands of modern heavy-duty Cat Diesels are on the job in every corner of the world. And still the research continues. Study and experiment go ahead constantly in Caterpillar laboratories. Special testing machines help point the way toward new advances. Manufacturing techniques improve, too, in the world's largest diesel engine factory—where the quality of workmanship is the standard for the industry.

A modern world must have modern power—more and more of it. It is coming, in ever increasing quantity, from the production lines of Caterpillar, the leader.

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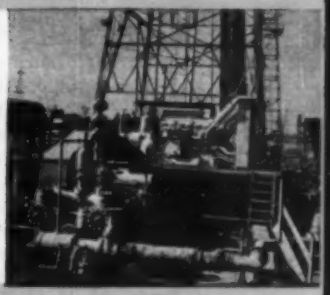

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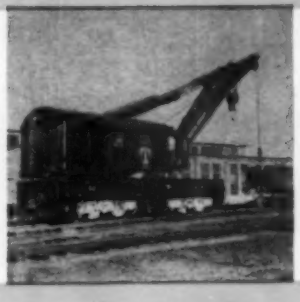

ANOTHER AID TO

communication

Departments and individual employees need immediate and accurate information about contracts. This need is met at Warren Petroleum through use of "digests" of contracts, which provide an efficient and economical method of good communication

Maxine R. Hacke

A UNIQUE department in Warren Petroleum Corporation is adding another chapter to the volumes of material written about "better communication" within a company.

Some years ago a Warren attorney, faced with the problem of channeling immediate and accurate information concerning contractual transactions, came up with the idea of briefs or digests of contracts, which could be circulated to various departments. Rather than make numerous copies of each contract (an expensive process) and require the many different departments to assign personnel to read and analyze the contracts (an even more expensive process), why not assign one person to read the original contract, abstract information pertinent to daily company operations, and circulate the abstracted material to those who needed it? His idea was adopted, and today the Records Control section of the office of the secretary is carrying on this work.

First, let's consider just what records are involved. We begin with the completed contract; all negotiations by the operating department are finished before Records Control enters the picture. (The exception to this rule is discussed later.) Then, all amendments, letter agreements or correspondence altering or affecting the contract follow. Notice that the department does not maintain a central filing system—correspondence, contract drafts, etc., during negotiations, and general correspondence between the parties thereafter, remain in the department which initiated the contract.

Now, the exception: As you know, sometimes the meaning of a contract is difficult to put into words, although the understanding between the parties is clear and operations can begin before signing the written contract. In these cases, Records Control receives either a copy of the draft of the contract together with information concerning status of negotiations, or a memorandum outlining the procedure to be followed until the formal contract is signed. Then, information is relayed to the various departments.

All types of contracts are included in Records Control—sales and purchases of products, construction and operating agreements, etc. Records Control is in the unique position of having an overall picture of Warren's entire operations. But—we've run into another exception. All good rules have them, you know. If it is a type of contract which concerns only one department, i.e., where all operations under it are carried on by a single department, then it will not come to Records Control. It is simpler and more efficient to leave the mechanics of the contract in that department.

That feature of Records Control must be emphasized. Its function is to minimize the work in handling contracts and disseminating information; and our procedures are kept flexible so

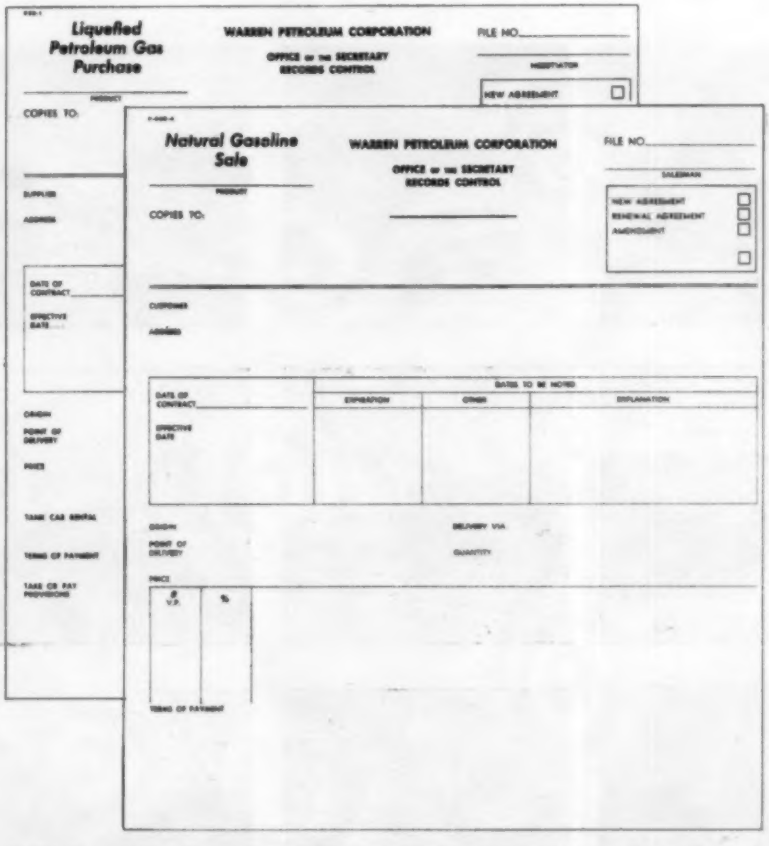

FIG.1 Examples of forms used for "Digests" of contracts covering sales and purchases of products.

that we may attain the result we're seeking. Obviously, to bring into Records Control a type of contract under which all operations are handled in one department duplicates work—and that we desire to avoid.

Determination of what contracts fall into this category of exceptions results from conferences between the operating department and Records Control, with final decision resting in the office of the secretary.

For the purpose of this article, we shall consider only those contracts which have been completed; i.e., those signed and ready for action.

The first step is review of the contract by the Contract Analyst. The Analyst reads the contract, determines what the transaction encompasses, what departments will be concerned, and when the information needs to be transmitted.

The Analyst reads the contract very carefully. You are no doubt familiar with legal phraseology and contract provisions, and agree that reading them is no small chore. But at least, the Analyst is relieving several others from having to do the same thing.

Sometimes the Analyst must consult the operating and/or the Legal Department to make sure that he understands the contract. It is of primary importance that a digest convey the exact meaning of the contract. It may happen that there is no brief way to convey the meaning of a provision—so, the entire provision is copied into the digest. But more often, there is a simple way to state the agreement which has been made. Then, too, many provisions apply only to situations that may arise in the future; in these cases, we can simply call attention to their presence, but do not need to digest them.

Here we wish to make it doubly clear that when a question arises between contracting parties, the contract itself is referred to for the answer. Our digests are for interdepartmental and day-to-day use only; and they should not be used to settle disputes nor for solving legal questions.

Now, back to writing the digest. When the Analyst has the transaction well in mind, his next step is to write out the digest. This can be done either in longhand or by dictating to a stenographer. Five digest forms are used at Warren (Fig. 1): (1) Liquefied Petroleum Gas Sale, (2) Liquefied Petroleum Gas Purchase, (3) Natural Gasoline Sale, (4) Natural Gasoline Purchase, (5) Information Notice. As you can see, the forms are simple and easily adaptable to any type of business. At the top of the page appears the file number, the name of the person who negotiated the contract (who should be consulted when questions arise); also, a place is provided to show whether the digest itself encompasses a new contract, a renewal or an amendment. Then appears a list of the persons who received a copy of the digest. Next, the file title and the name and address of the other contracting party.

The box in the middle of the page is used to call attention to important dates in the contract—when it is effective, when it will expire, and any other dates on which events may occur in the future.

The first item in the body of the Information Notice digest (Fig. 2) is the Purpose of the contract—a brief explanation of the reason for the contract. As an example "Construction of a loading rack to serve a gasoline manfacturing plant located in Tulsa, Tulsa County, Oklahoma." Then follow the various contract provisions, readily identifiable by the use of captions denoting the information contained in each section. In the case of sale or purchase digests, information concerning origin, delivery, quantity, price, etc., appear first, and are followed by any other pertinent data contained in the particular contract.

When he has completed writing or dictating it, the Analyst assigns the digest to a stenographer to type. Sometimes as many as 15 persons, in 6 or more departments, may need to know about some feature of the contractual relation. For reproducing the digest, we use multilith mats. All of the language appearing on the forms shown in Fig. 1 is pre-printed because it is required in every digest written. The digests are typed directly onto the preprinted mats, which are sent to the Reproduction Department for printing, and then returned to Records Control where the copies are distributed.

The mats are stored and used again whenever necessary, a process which reduces typing work considerably. An amendment of a contract frequently affects only one or two of its provisions and, therefore, we may need to change only a few words in the digest. The stenographer simply erases the original wording, types in the new provision, and sends out the same mat for printing. The box at the top right-hand side of the digest (see Fig. 1) indicates the

Information Notice

Construction Agreement

WARREN PETROLEUM CORPORATION

OFFICE OF THE SECRETARY
RECORDS CONTROL

FILE NO. 1000
John Doe
NEGOTIATOR

January 1, 1956

NEW AGREEMENT ☑
RENEWAL OR EXTENSION ☐
AMENDMENT ☐
☐

COPIES TO:
John Doe
Richard Roe
Purchasing Dept.
Accounting Dept.
Insurance Dept.
Materials Dept.
Tax Dept.

FILE TITLE: BLANK PLANT NO. 000 - CONSTRUCTION

CONTRACT WITH: Plant Construction Company

ADDRESS: 0000 East Avenue
Tulsa, Oklahoma

DATE OF CONTRACT	DATES TO BE NOTED		
	EXPIRATION	OTHER	EXPLANATION
EFFECTIVE DATE January 1, 1956	Completion of Work	March 15, 1956	Date on which 1/3 of contract price is due and payable to Contractor.

PURPOSE: Construction of a Loading Rack to serve a gasoline manufacturing plant located in Tulsa, Tulsa County, Oklahoma.

CONTRACT PRICE -

PAYMENT -

SCOPE OF WORK -

MATERIAL FURNISHED BY WARREN -

MATERIAL FURNISHED BY CONTRACTOR -

INSURANCE -

INDEMNITY -

ASSIGNMENT OR SUB-CONTRACTS -

FIG. 2. Examples of item headings in digest of construction contract.

reason for issuing the digest, and the recipients simply replace the original digest with the new one.

Each department has its own method for filing the digests. For example, in Records Control we file them alphabetically according to the file title. However, another department may find it more suitable to file them according to the name of the other contracting party. In either case the digests are kept in three-ring notebooks and are easily accessible.

Indexing Contracts

Now, let's discuss indexing the contracts in Records Control. Since they are available for use by all departments, they must be easy and quick to find. Probably, methods of indexing are as numerous as there are companies using indexes. We use the simplest ones we know: Numerical, Alphabetical (including cross-references), Type and Date Control.

When requesting a contract, company personnel usually refer to (1) location, (2) person or firm involved, or (3) nature of the transaction. Rarely do we receive requests for files by number—which is just as well, because it's so easy to transpose numbers and request the wrong contract.

Upon receipt of a contract in Records Control, it is assigned a File Number from our Numerical Index. The file is given a title, and both the number and title are typed on the file label. The file folders are placed in drawers in numerical order.

Next an Alphabetical Index card is made by inserting the file title and number at the top. Our titles are descriptive as far as possible; for example, all contracts pertaining to one plant are given titles beginning with the plant name, such as "Blank Plant No. 000 — Construction" or "Blank Plant No. 000 — Operating Agreement" and so on. Thus, all agreements pertaining to one plant are easily located in the alphabetical index.

To find contracts with individuals or companies, a cross-reference card, bearing the individual or company name at the top and reference to the file number and title in the body of the card, is also filed in the Alphabetical Index.

Besides finding the file according to its title or contracting party, the alphabetical index serves an additional purpose. It is a permanent index of each instrument placed in the file folder. The date of the contract, names of parties to the contract, and a brief explanation are itemized on the card. Then, if an instrument is called for which does not appear in the file, we can determine whether it was received in Records Control, or was received and has been removed from the file. It is our company policy that no instrument is to be removed from the file; when a department calls for a contract, the entire file is sent. When absolute necessity requires removal, Records Control secures a photostat of the instrument before releasing it.

A third card file is maintained according to the type of contracts — called the Type Card Index. All contracts of a similar nature, regardless of contracting party or location of facility, are indexed together, e.g., all construction contracts or all operating agreements. This index provides a correlation of similar contracts.

Date Control

Another service by this department is the "Date Control." We use a visible tab card file system, and call attention to events which will occur according to the provisions of the contract. The information is placed on the card form (see Fig. 3) and filed in order according to the dates. Each month we issue to each department a Date Control Notice which calls their attention to contracts which will expire, or which require some action to be taken or allow the parties to take some action at their discretion.

These notices are scheduled to give at least 60 days notice to the affected department, so that it may be prepared to meet the contract requirement. Records Control follows up these notices, ascertaining whether either party did take action or if our permanent record should be noted in any way. This practice enables us to keep our files up to date at all times.

Periodically Records Control issues an Expiration Notice. This notice includes all contracts which have expired or have been terminated, and each department is requested to withdraw and destroy the digests from its active digest book. The result is that only active contract digests are retained in the departments.

Contract Files

Our contract files are available at all times to any authorized person or department which needs them. They are checked out to the person requesting them, and a periodic survey is made to determine where the files are, and

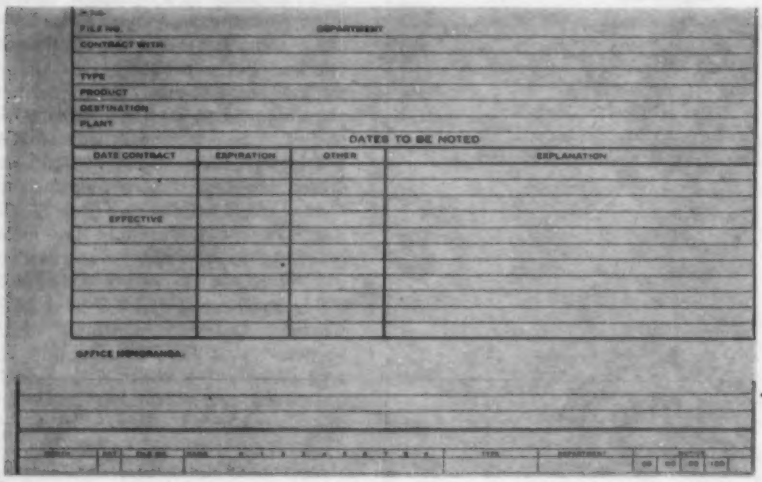

FIG. 3 Form of visible tab index card used in Date Control system.

The Author

Miss Maxine R. Hacke is supervisor of Records Control for Warren Petroleum Corporation. She joined Warren in June, 1945 as lease records clerk in the oil division, first at Tulsa, Oklahoma, and then in Houston, Texas.

A native of Tulsa, she was educated there and at the present time is working toward her law degree at the University of Tulsa. As supervisor of Records Control, she is in the office of the secretary of the corporation at the Tulsa headquarters of the company.

Miss Hacke is an active member of the Desk and Derrick Club of Tulsa.

when they can be returned to us. Records Control personnel may be contacted at all times to give information in a contract to anyone who needs immediate detail on the telephone.

Personnel

This brings up the question of the people assigned to this department, and what their qualifications must be. We have previously indicated that the work here gives an overall picture of company operations. The work requires a complete knowledge of the aims and operations of the company, so that the Analyst, for example, is able to recognize the type of contract he is examining, what its purpose is and who in the company needs to know the detail contained therein.

Since he is examining and reading legal documents constantly, he must have legal training and an ability to understand complicated phrasing. Above all, he must be able to read—and if this sounds peculiar (because we are all business people who read all the time) it really isn't. Many people know what words are written on the page, and they may be able to put a group of words together and come up with a meaning; but if they miss one or two words in a group, they can come up with a meaning entirely different from the one actually intended!

Another important qualification required in the Analyst is the ability to get along with people. Since the department is concerned with almost all of the company operations—real property transactions, manufacturing of products, marketing of products, accounting and so on—it is often necessary to consult with other personnel. He cannot be expected to understand all there is to know about all of the contracts, but he must be able to ask questions and to comprehend the answers. He must avoid irritating his associates by frequent and unnecessary visits and consultations. He should have his problem well in mind, state it clearly, be sure he understands the answer, and use a minimum of time in doing it all.

Sounds like the perfect individual, doesn't it? But, of course, there aren't any qualifications mentioned that aren't required of most business people.

Records Control is a system easily adapted to all situations. For more than 10 years it has been found to be a practical and efficient method of communication within our company. ★ ★ ★

DURA SEAL
The Engineered Mechanical Seal
21st Year
DURA SEALS provide perfect sealing on rotating shafts on processing equipment for the widest range of fluids, pressures, temperatures and speeds.
The PERFECT SEAL
DURAMETALLIC CORPORATION
KALAMAZOO MICHIGAN

OIL LOANS . . .
Your production needs can be satisfied with a loan at . . .
MEMBER FEDERAL DEPOSIT INSURANCE CORPORATION
NATIONAL BANK OF TULSA
The Oil Bank of America
OFFERING COMPLETE BANKING AND TRUST SERVICES

It's an old enemy that searches for cracks in your resistance . . . Serious illnesses can begin with signs of a cold

The Too Common Cold

Dorothy Carlson, R.N.

COLDS constitute a menace, actual and potential, to human health and entail heavy economic loss upon the individual, community, and nation. They are more costly in time lost than any other single ailment. Available statistics indicate that the national economy and education suffer enormously in both time and efficiency, as the cold keeps more men and women sick at home and more children out of school than any other illness.

With the arrival of winter, respiratory diseases are more prevalent and the average person suffers from one to four attacks each year, varying from runny nose to the coughs, sneezes, and misery of a bad one. Three main peaks of incidence usually are reached. The first occurs in October and November, a second in January, and the third in March and April. About one-fourth of the people in the United States have three or more colds a year. More than half of all the people have at least two colds a year, and only a small proportion have only one cold a year.

Since the cold is a disease that the average person endures two or three times a year, each individual should recognize its dangers, be more concerned about its care, and use greater precaution against spreading it to others.

Because colds are so common, people tend to ignore them. It seems to be a general feeling that they are not dangerous and that nothing can be done about them anyway. Many serious illnesses start with signs of a cold, and continued colds may pave the way for pneumonia, tuberculosis, or chronic eye, ear, nose and throat infections.

Many physicians will tell you that there is no common sickness the doctors know less about — or that the victims think they know more about — than the common cold. Although there are no generally accepted scientific conclusions as to the cause of colds, it is believed they are caused by a filterable virus, and transmission is direct by droplet infection through sneezing or coughing.

Some colds are spread rapidly from one person to another, while at other times the disease is limited to one person in a group. For this reason it appears that susceptibility plays a major role in its development. Some lucky people seem to have a natural resistance while others apparently catch a cold at every opportunity. The degree of susceptibility varies from one person to another from year to year.

Because medical authorities have much to learn about the ailment, it is difficult intelligently to develop effective measures of prevention. Medical research has shown, however, that there are certain factors which may cause some colds. To avoid these factors, one might observe the following rules:

1. **Keep out of drafts.**
2. **Keep dry.**
3. **Avoid, if possible, hot, dry, stuffy rooms.**
4. **Dress according to the weather.**
5. **Eat a well-balanced diet with lots of liquids.**
6. **Keep clean — wash hands frequently and keep them away from the nose and mouth as much as possible.**
7. **Get plenty of rest.**
8. **See your doctor when severe symptoms appear.**

The exact incubation period of a cold is unknown. However, the cold is very contagious, especially during the first 24 hr. There is little doubt that the most important treatment is rest in the even temperature of bed. To protect yourself and others, one should avoid doing anything that might spread or extend the infection.

Outside influences, such as getting too warm, too tired, or any other excess, can weaken us and make it easier to catch cold. But we never have a cold unless we have been exposed to the cold virus. Chilling by itself will not cause illness. It can, however, lower resistance to an attack by an infectious agent such as the cold virus.

On the whole, drugs exert little influence on the course of infection. It is doubtful, at present, that any drug can *cure* a cold. Millions of dollars are spent every year for cold drugs, and it is noticed that the labels of most reputable cold drugs now state that the particular drug "will aid in removing the discomforts due to colds." In other words, the irritations of a cold are soothed by some drugs. However, before taking some of these drugs, a physician should be consulted. A remedy that is safe and effective for one person may be harmful to another.

Cold vaccines are controversial at present, but extensive studies being conducted indicate some effectiveness. The use of influenza virus vaccine by large industries, the armed forces, and institutions has either eliminated or modified epidemics of influenza and upper respiratory infections. In a large industry in the eastern part of the United States, experience during the last few years has led to the belief that 90 per cent of the people are benefited by the vaccine.

While a certain degree of immunity develops as the result of a cold, it is of short duration, usually lasting no longer than from several weeks to a few months.

In summary, then, it is suggested that good hygiene, such as washing hands before meals and avoidance of contact with persons having colds, may aid considerably in preventing colds. Also of probable help in preventing colds is the wearing of proper clothing and avoidance of chilling, dampness, and fatigue. Try to keep your general resistance high at all times. If you do get a cold, be alert to any signs of secondary infection. ★ ★ ★

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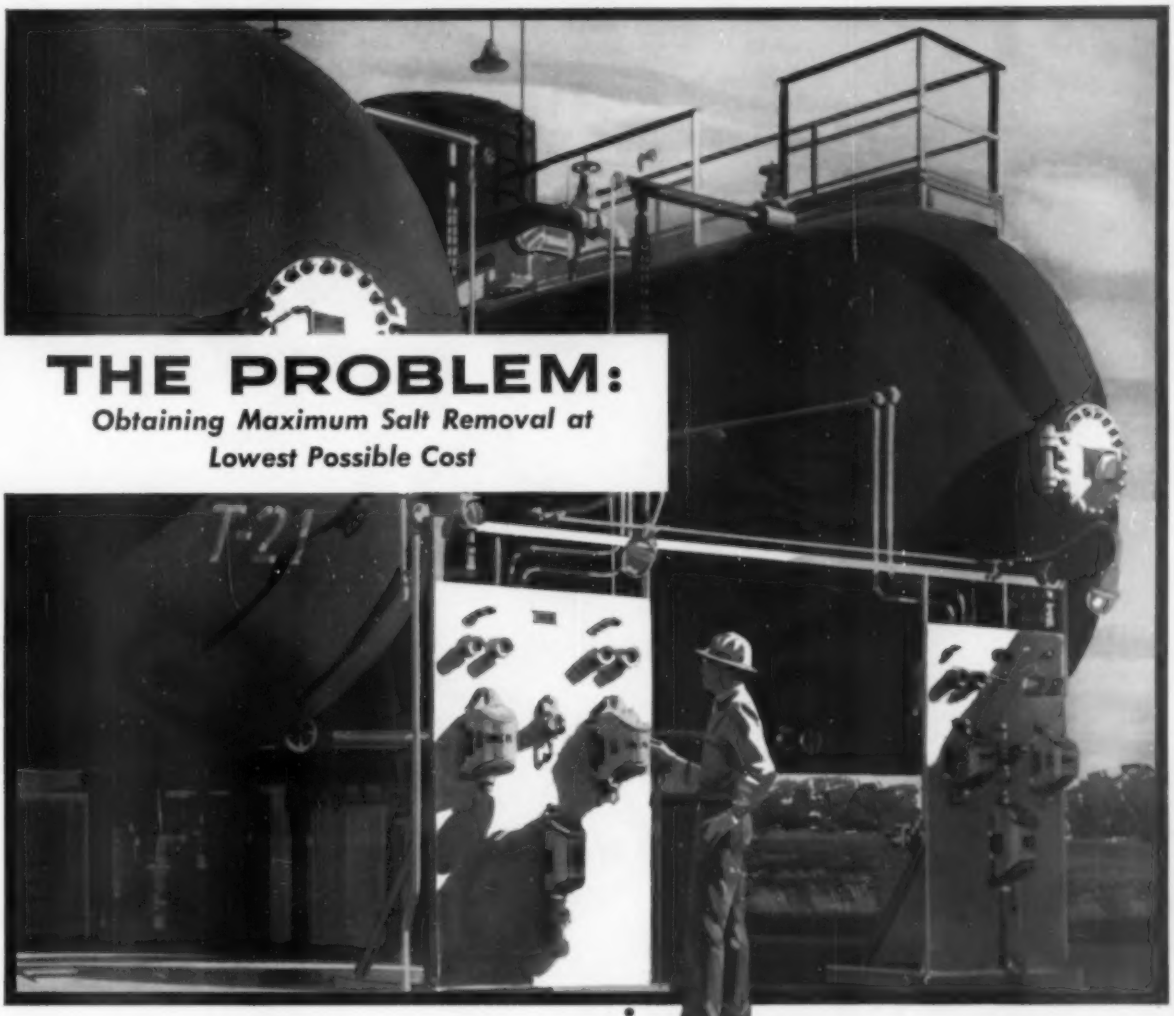


THE PROBLEM:

Obtaining Maximum Salt Removal at Lowest Possible Cost

THE SOLUTION

Humble's Efficient Desalting Chemicals —

BREAXIT

Humble's *Breaxit* desalting chemicals result from years of specialized study and experimentation by a company that has problems similar to your own.

Breaxit desalting chemicals give you maximum salt removal in the settler drums to assist you in getting longer refinery runs. These products also save you money by increasing throughput, adding to refinery efficiency, and extending equipment life. Furthermore, continued use of *Breaxit* will provide you with safer operations.

At your request, experienced engineers from Humble's Technical Service Division will make a study of your desalting problems and give you specific recommendations for their solution. This service is without cost or obligation.

For complete information on *Breaxit* desalting chemicals, write or phone:

Technical Service
Sales Department
Humble Oil & Refining Company
P. O. Box 2180
Houston 1, Texas

HUMBLE

HUMBLE OIL & REFINING COMPANY

LADISH

SEAMLESS

Multiple Outlet FITTINGS

TO MARK PROGRESS

Typical fittings and piping layout of coils in a charge heater.

LADISH DESIGNED 90° AND 45° ELBOWS

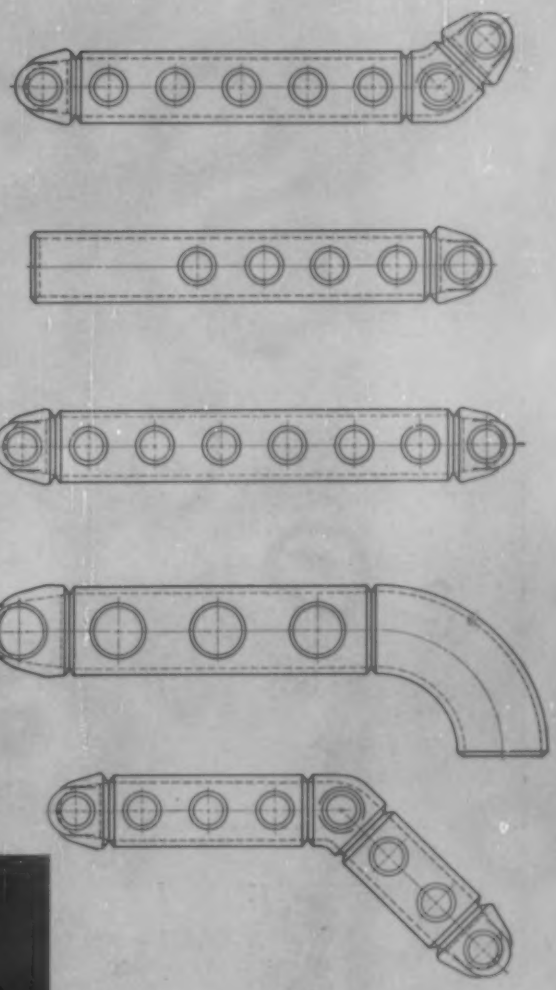
PATENT PENDING

Special die-forged Ladish 90° Reducing Heater Elbow provides a lower cost, easier to make up, final outlet and end closure. Obsoletes expensive, heavy-volume fillet weld required on straight blank-off design. Pressure drop is minimized and flow efficiency improved. Residue collecting pockets and stress risers at critical locations are eliminated. Provides ample clearance between fittings for ease of installation and more expansion allowance.

Ladish forged 45° Side Outlet Elbow effects positive savings in time and cost over the undesirable miter joint otherwise necessary. Eliminates time-consuming angle cutting and welding —then scribing, torching and nozzling-in of outlet directly over miter joint. Only two, easy-to-make circumferential butt welds required . . . deposition of weld metal at this critical juncture is minimized.

IMPROVE FLOW EFFICIENCY ...SAVE PIPING ERECTION COST IN HEATER INSTALLATIONS

Illustrated here are typical combinations of Ladish Multiple Outlet Fittings, 90° Reducing Heater Elbows and 45° Side Outlet Elbows produced to meet design requirements for heaters with varying flow cycles.

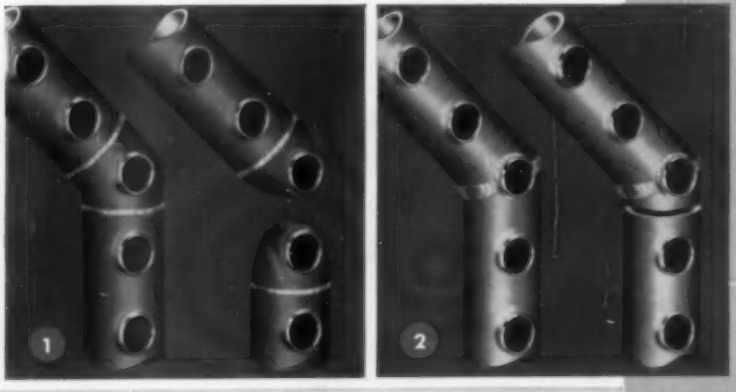


SEAMLESS Multiple Outlet Fittings developed and produced by Ladish . . . offer you significant design advantages and installation and operational economies.

Only simple circumferential welds are required to join the integral outlets to heater tubes. Expensive nozzling-in and reinforcing operations are eliminated.

Ladish 90° Reducing Heater-Elbows and 45° Side Outlet Elbows used in combination with Ladish Seamless Multiple Outlet Fittings further cut installation costs . . . improve both design and flow efficiency.

These fittings are manufactured in a wide range of sizes and material specifications to the same rigid metallurgical and manufacturing standards which distinguish Ladish Controlled Quality Fittings.



1 Ladish streamline design simplifies installation, improves flow efficiency and assures ample expansion allowance between coil sections.

2 Obsolete miter joint construction leaves insufficient space between coil sections, complicates installation, restricts expansion.

THE COMPLETE *Controlled Quality* FITTINGS LINE

LADISH CO.

CUDAHY, WISCONSIN
MILWAUKEE SUBURB

District Offices: New York • Buffalo • Pittsburgh • Philadelphia • Cleveland
Chicago • St. Paul • St. Louis • Atlanta • Houston • Odessa • Tulsa • Denver
Los Angeles • San Francisco • Seattle • Havana • Mexico City • Brantford, Ont.

LADISH CO.
Cudahy, Wisconsin

We're interested . . . have Ladish representative call to discuss our application.

Name _____ Title _____

Company _____

Street _____

City _____ State _____

PEM

Youngstown's "big 5"

HELP SOLVE YOUR OIL OR GAS LINE PROBLEMS, WHEREVER YOU ARE

Here are the "Big 5" reasons why Youngstown Electric Weld Line Pipe is your best buy:

1. It bends readily
2. Wall thickness is uniform
3. Line up characteristics are excellent
4. Weldability is outstanding
5. Long lengths save you time and trouble

It's no secret that installation crews prefer Youngstown Electric Weld Line Pipe for its easy line-up qualities. Good line-up is a direct result of the extra care that goes into its manufacture. To achieve the optimum in roundness, each length of Youngstown Pipe is placed in an hydrostatic expander, here, internal water pressure forces the pipe out against the solid steel walls of the mantle. The diameter of the pipe is thereby increased to a uniformly accurate size. Every length conforms to specifications—ends are truly round, uniform in wall thickness, squarely cut and properly beveled for welding. These excellent line-up characteristics are more evidence that it pays to specify Youngstown Electric Weld line pipe.

Youngstown

ELECTRIC WELD LINE PIPE

QUALITY YOUNGSTOWN SERVICE

THE YOUNGSTOWN SHEET AND TUBE COMPANY *Manufacturers of Carbon, Alloy and Yoloy Steel*

General Offices: - - - Youngstown 1, Ohio.

Ben C. Belt of Houston, Texas, and **Robert B. Anderson,** of New York City have received the Texas-Mid-Continent Oil & Gas Association's distinguished service awards. Above, **I. P. LaRue,** (left) Athens, Texas, is presenting the award to Belt. Belt now works as a petroleum consultant and heads Houston, Texas' Chamber of Commerce. Anderson (left) is receiving his award from **Hines Baker,** president of Humble Oil and Refining Company. Anderson was named Secretary of the Navy by President Eisenhower in 1953 and became Deputy Secretary of Defense in 1954, resigning in 1955 to return to private business.

PERSONALS

▸ **M. S. Hauser,** public relations director of The Ohio Oil Company, has been elected 1957 national chairman of the Oil Industry Information Committee—the petroleum industry's public relations program.

Hauser succeeds **Richard Rollins,** secretary of The Atlantic Refining Company. Hauser will assume the chairmanship at the OIIC's next meeting in New York in December.

Vice chairmen elected are **Kerryn King,** The Texas Company; **Dwight M. Hills,** Sinclair Refining Company; **James M. Patterson,** Standard Oil Company (Indiana); **Joe T. Dickerson,** Shell Pipe Line Corporation, and **G. Stewart Brown,** Standard Oil Company of California. **John S. Cooke,** American Petroleum Institute, New York, was re-elected secretary.

▸ **Clayton L. Orn,** general attorney of the Ohio Oil Company, has been elected chairman of the mineral section of the American Bar Association.

▸ **John E. Swearingen,** vice president in charge of production, and **Dr. Robert C. Gunness,** general manager of supply and transportation, were elected executive vice presidents of Standard Oil Company (Indiana).

Dr. Max G. Paulus, former vice president in charge of manufacturing, has retired. **Samuel A. Montgomery,** general manager of manufacturing and a director, was elected vice president to succeed Dr. Paulus.

Also announced was the election of **Thomas E. Sunderland,** general counsel, to vice president and general counsel. **Joseph K. Roberts,** general manager of the research and development department, was elected vice president in charge of research and development. **George V. Myers,** general manager of production, was elected a director. **Jesse C. Ducommun,** assistant general manager of manufacturing, will succeed Montgomery as general manager of manufacturing, and was also elected a director.

▸ **C. F. Mantooth** has been appointed manager of publicity of the Sinclair Oil & Gas Company, Tulsa, Oklahoma.

▸ **T. M. Kerr,** formerly executive vice president of Kerr-McGee Oil Industries, Inc., has been elected vice chairman of the board of directors.

F. C. Love, formerly general vice president, will become executive vice president. **A. T. F. Seale,** formerly vice president of manufacturing, will become vice president of operations.

W. M. Murray has been named vice president of general sales, **R. M. Chesney** vice president of refining, and **J. W. Roach** vice president of crude oil supply, pipe lines, and refinery technical services. **G. B. Parks,** formerly manager of production and drilling operations, has been elected vice president of production and drilling.

▸ **B. Brewster Jennings,** chairman of the board, Socony Mobil Oil Company, will serve as chairman of the national convention committee of the 43rd National Foreign Trade Convention to be held at the Waldorf-Astoria, New York, November 26-28.

▸ **Harvey Cash** has been appointed assistant to the chairman of The Texas Company. Cash has been general manager of Texaco's foreign operations department-Eastern Hemisphere.

He graduated from Texas A&M College with a BS in electrical engineering in 1933 and joined The Texas Company in the same year.

▸ **Bryson M. Filbert** has joined the administrative office of International Petroleum Company, Ltd., Coral Gables, Florida, as manufacturing advisor. He transferred to International from Humble Oil and Refining Company, where he was the chemical products coordinator. He received his BS in chemical engineering at Pennsylvania State University in 1936.

Wayne R. Hierseman has joined the administrative office of International Petroleum as senior economist. He received a BS in chemical engineering at Iowa State College in 1950 and a master's degree in business administration from Harvard University in 1952.

▸ **P. C. Spencer,** president of Sinclair Oil Corporation, has been elected to Texas Pacific Coal and Oil Company's board of directors.

DEATHS

▸ **George Rider,** 67, vice president of the Sun Oil Company died August 7, in Santa Monica hospital after a long illness.

▸ **Ernest R. Love,** vice president of A. D. Rushing Drilling Company, died in London following a heart attack.

▸ **Donald L. McClure,** 49, recently appointed general manager of the Corrulux Division of the L. O. F. Glass Fibers Company, Rossford, Ohio, died of a heart attack on September 14 in Houston, Texas.

▸ **Anthony (Tony) F. Stadler,** senior buyer for Jones & Laughlin Supply Division, was killed in an automobile accident September 1.

▸ **Sam P. Shelburne,** 68, official of Jones, Shelburne & Pellow Oil Company and Julian Oil and Royalty Company, both of Oklahoma City, Oklahoma, and Jones, Shelburne & Farmer of Russell, Kansas, died at home September 7 after a brief illness.

▸ **Joseph A. Birkhead,** 58, sales representative of the Lunkenheimer Company of Cincinnati, Ohio, died in Houston, Texas, on September 2, following a long illness.

▸ **Charles Robert Stewart,** 76, a pioneer of the American pipe line industry, died after a long illness. His pioneer work was recognized a few years ago by a special award recognizing him as "Dean of the Oil Industry Pipeline Association."

▸ **Al Hamill,** 80, employee of the drillers of the Lucas oil gusher at Spindletop, Texas, died due to cancer. Hamill and his brother were the first to use the rotary method of drilling.

LAUGH with BARNEY

A woman flees from temptation, but a man crawls away from it in the cheerful hope that it may overtake him.

* * *

It seems that two middle-aged women rented a summer cottage sight unseen. When they arrived, they found it so isolated they were terrified. After a few frightened nights they paid the old man, who did odd jobs, to sleep in a shed near their door every night. The next summer they took the place again and went to look up the old man. At his cottage they found a sign posted: "Wood supplied, odd jobs done. Narvus wimmen slept with."

* * *

Somewhat overwhelmed by a eulogistic introduction praising his charms, talents and ability as a speaker, big business tycoon faced his audience: "Gentlemen," he began, "I can hardly wait to hear what I'm going to say."

25 YEARS of Experience in Correcting SCALE, CORROSION, ALGAE Problems

D. W. HAERING & CO., INC.

ANALYSTS • CONSULTANTS • MANUFACTURERS

SAN ANTONIO, TEXAS

"Everybody all set back there?" called the bus driver.

"Wait just a minute," a girl's voice said, "until I get my clothes off."

Every head in the bus swung around—to see a girl step off the bus carrying two packages of laundry.

* * *

A hillbilly came to town carrying a jug of spirits in one hand and a shotgun in the other. He stopped a man on the street, saying—"Here, friend, take a drink outta my jug."

The man protested he didn't drink.

The hillbilly leveled his shotgun at the stranger and said, "Drink."

The stranger drank and then he shuddered, shook, shivered and coughed. "Gad, that's awful stuff."

"Ain't it?" said the hillbilly. "Now hold the gun on me while I take a gulp."

* * *

"What do you take for your insomnia?"

"A shot of bourbon at regular intervals."

"Does that make you sleep?"

"No, but it makes me happy to stay awake."

* * *

A man was very indignant at being arrested. He staggered into the police station and before the captain had an opportunity to say anything he pounded his fist on the desk and said: "What I wanna know is why I've been arrested."

"You were brought in for drinking," answered the captain.

"Well, thass different — thass fine — let's get started."

* * *

The day was rainy and the cellar leaked. Bertram, 5, was having a wonderful time sloshing around in the water when his mother caught him, soaked to the skin. As punishment he was ordered to stay in his room until his pants were dry.

A short time later his mother heard a commotion in the basement. "Are you down there wetting your pants again?" she bellowed.

There was a long pause and then a deep masculine voice replied: "No, Ma'am, I'm just reading the meter."

* * *

The inmate had his ear pressed up against the wall.

"Listen!" he whispered.

The new attendant listened intently, then finally confessed: "I don't hear a thing."

"I know," the inmate said darkly. "It's been like that all day."

* * *

Two small boys held out their hands side by side on the white tablecloth.

"Mine's dirtier than you'rn!" exclaimed one, triumphantly.

"Huh!" snorted the other disdainfully, "you're two years older'n me."

* * *

A fire in a backstage ladies' dressing room was put out in one hour and then it took five hours to put out the firemen.

* * *

Maisie was in a bar having a beer when a friend from England walked in.

"Aye say, Maisie, are you 'aving one?"

"No, it's just the cut of me coat."

* * *

King Arthur: "I hear you've been misbehaving lately."

Knight: "In what manor, Sir?"

Philosophy Is Her Hobby

A quick decision brought **Ruth DeWitt** to her position today as senior attorney on the legal staff of Sun Oil Company's southwest division. From a family that "had everything else but a lawyer," Ruth suddenly informed a geologist friend back in 1928 that she was going to study law. And she did.

Up to that time Ruth had attended New Hanover County High School in North Carolina, and majored in

Ruth DeWitt

English and French at the University of Chicago, where she received her PhB in 1927. To start on her new career, Ruth enrolled in the law school of University of Tulsa. At the same time she served as a stenographer in the legal department of Twin State Oil Company, now a Sun division.

With her LLB degree in 1932, Ruth moved to Sun's Dallas, Texas, office in the legal department. Though she passed the Texas State Bar exam in 1934, it was not until 1941 that she officially became a full-fledged attorney on the Sun staff.

She has been successful in handling legal matters, largely pertaining to land law, for a decade and a half.

As a change from the study and practice of law Miss DeWitt switches to the study of moral philosophy as her chief hobby. Recently she served as the leader of a Great Books group in Dallas. For recreation she enjoys bowling, swimming and mows her own lawn.

30 Years With Shell

Over 30 years ago **Pauline H. Short** joined Shell Oil Company in Ponca City, Oklahoma, and today reports that she is always proud to say "I work for Shell." Now serving as secretary to the division exploration manager in Wichita, Kansas, Pauline wears a two-diamond service pin.

After retirement Pauline hopes to make charitable work her hobby-avocation. She is a charter member of Oil Secretaries Association and past president of The Travelers Club, a social travel-interest group.

Mrs. Pauline Short

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BOOKS ★

Industrial Lubrication Practice, *By Paul D. Hobson, published by The Industrial Press, 93 Worth Street, New York 13, New York. Pages, 548. Price, $8.00.*

Scope of this book is much wider than the name implies. Lubrication is presented more as an approach to discussions of different types of prime movers than as an end in itself. The work does provide a most informative survey of the many oils, greases, and solid lubricants, both natural and synthetic. Different kinds of plain and anti-friction bearings are described and the ways in which they function are discussed.

A separate chapter is devoted to each type of prime mover, complete with operating data on each. Important factors in the lubrication of industrial machinery and equipment for metal forming and metal cutting are presented and various coolants used in metal-cutting operations are described. Organization of a lubrication department is set up by the author. There is much material about the deterioration of oil during its use, the decomposition products that are formed, and the effects on machinery. Contaminants are discussed, with ways in which gravity separation, centrifuging, and filtration equipment can be employed to purify used oil.

Tables of Thermal Properties of Gases, *by Joseph Hilsenrath, C. W. Beckett, W. S. Benedict, Lila Fano, H. J. Hoge, J. F. Masi, R. L. Nuttall, Y. S. Touloukian, and H. W. Woolley, National Bureau of Standards Circular 564. Obtainable from the Government Printing Office, Washington 25, D. C. Pages, 478. Price, $3.75.*

One of a series of compilations of thermodynamic and transport properties of gases published by the Bureau, this collection of tables covers air, argon, carbon dioxide, carbon monoxide, hydrogen, nitrogen, oxygen, and steam. The tables are data on the physical properties of substances of technical and scientific interest. Advances in high-speed flight are particularly dependent on precise knowledge of the behavior of construction materials, the physical and chemical properties of fuels and oxidizers, and the atmosphere.

Tables are given at close temperature intervals for the thermodynamic and transport properties of the gases covered. The thermodynamic properties — compressibility factor, density, entropy, enthalpy, specific heat, specific-heat ratio and sound velocity — are tabulated for the real gas at pressures up to 100 atmospheres and to temperatures of 600 deg Kelvin for hydrogen, 1500 deg Kelvin for carbon dioxide, 850 deg Kelvin for steam, and 3000 deg Kelvin for the remainder. The ideal-gas thermodynamic functions are tabulated uniformly to 5000 deg Kelvin. Also tabulated are the vapor pressures and transport properties, thermal conductivity, viscosity, and Prandtl number.

Fuels: Solid, Liquid and Gaseous, *by J. S. S. Brame and J. G. King, published by Edward Arnold, Ltd., London. Obtainable through St. Martin's Press, Inc., 103 Park Avenue, New York 17, New York. Pages, 551. Price, $10.00.*

Fifth edition of this book has been almost entirely rewritten by Dr. King, formerly superintendent of the Fuel Research Station. The major advances in fuel technology in the last decade are discussed.

Advance in the methods of examination, control and economy in fuel usage, say the authors, is due to the much higher price levels of all fuels in recent years. This has meant a considerable increase in instrumentation in industrial processes. The authors discuss, among many things, pulverized coal, the conversion of coal to oil, by processes of hydrogenation or synthesis; catalytic cracking, secondary catalytic processes, aviation technique and increased importance of the kerosine fraction in the field of petroleum.

Thermodynamics, *by John Francis Lee and Francis Weston Sears, published by Addison-Wesley Publishing Company, Inc., Cambridge 42, Massachusetts. Pages, 543. Price, $8.50.*

Although written primarily for a one-year undergraduate course, this book is aimed at providing a mature approach to the basic principles of thermodynamics for all engineering and applied-science students, regardless of their ultimate professional objectives. With this view in mind, the authors have selected subject matter to offer a single basic course in thermodynamics for all students, instead of a number of specialized courses. Problems have been selected without regard to any particular field of professional specialization.

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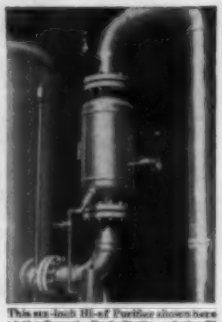

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OIL and GAS TRADE NEWS

Multi-Million Dollar to Modest Plant Expansion Plans in Offing

In the offing this month are plans for expansions ranging from multi-million dollar to more modest enlargements announced by numerous companies, with some already completed.

Diamond Alkali Company has reported two multi-million dollar expansion programs at its Deer Park Plant along the Houston Ship Channel near Houston, Texas.

First is a project designed to increase Diamond's present daily production capacity of electrolytic products by approximately 40 per cent, or 200 tons of chlorine, 220 tons of caustic soda, and 2,000,000 cu ft of hydrogen. These additional facilities are expected to be completed and put into operation during the first half of 1958. Diamond Alkali also will proceed with designing and engineering a facility for manufacturing acetylene. This proposed plant's construction is slated to start in the fall of 1957.

Byron Jackson Oil Tools, Inc., has completed construction of a new warehouse in Houston, which supplements the company's manufacturing plant and offices there.

A near-future investment of more than $50,000,000 is expected by The Dow Chemical Company at its Louisiana division at Plaquemine. Original announcement of plans last February called for an investment estimated at $20,000,000.

Start of operations is scheduled for the spring of 1958.

When running at full capacity, the Louisiana division will produce caustic soda in regular and rayon-grade solutions; chlorine; gylcols and oxides of ethylene and propylene; chlorinated solvents, including carbon tetrachloride, ethylene dichloride, perchloroethylene and trichloroethylene; vinyl chloride; hydrochloric acid, and other products.

Associated Oil Field Rentals has said it will open a branch rental yard in Morgan City, Louisiana, to supply both inland and offshore drilling equipment. The new yard will be the eleventh branch of the Houston, Texas-based tool rental firm.

Completion of a $2,000,000 building and expansion program at its Beaumont, Texas, plant which will boost substantially production of heat exchangers and oil field equipment has been announced by Alco Products, Inc. The plant makes specialty items and mass produces heat exchangers and well control equipment. Repair facilities also have been provided as well as large warehouse areas to stock both products turned out in Beaumont and those from other Alco plants.

To serve as headquarters for eight southern states, the computer division of Bendix Aviation Corporation has opened a branch marketing and service office in Dallas, Texas. This move is part of a development by which Bendix intends to create a nation-wide marketing and field engineering system to keep pace with growing demand for general-purpose computers.

Cal-Metal Pipe Corporation of Louisiana has disclosed that it is installing an electric-resistance weld continuous mill to produce API, ASTM, and AWWA-specification line pipe for the gas, oil, water, and construction industries at its Baton Rouge, Louisiana, plant. New mill will have a rated monthly capacity of 5000 to 7000 tons of standard and lightweight pipe in sizes ranging from 6-in. through 16-in. diam.

For the production of its gasoline-powered chain saws, Homelite, a division of Textron, Inc., has revealed that it will build a new 135,000-sq ft, modern, one-story factory in Gastonia, North Carolina. Construction of the plant will get underway in November, with full operation anticipated by the fall of 1957.

Worthington Shows Research Tool

A unique new research facility has been demonstrated by Worthington Corporation at its Harrison, New Jersey, research and development laboratory. The facility is a closed-circuit test loop with electronic digital computer. It is believed to be the first of its kind.

Worthington will use the loop for the testing and developing of new products, particularly new compressors for the air conditioning and refrigeration equipment it manufactures. The loop also will be used to determine performance ratings for production quality control.

Technically, the facility is an automatic, spray desuperheating, closed system. Nontechnically, it is comparable to a wind tunnel used in aircraft laboratories except that refrigerants are circulated through its giant pipes and tubes rather than a stream of air.

Thew Shovel Dutch Subsidiary

Thew Shovel Company has established a wholly owned Dutch subsidiary for the manufacturer and distribution of "Lorain" machines in Europe.

The new company, Lorain Holland, N.V., is located in The Hague, Netherlands. Warren B. Weston, director of overseas operations for Thew, also will be managing director of the new company. F. S. Battin, export sales manager of Thew in Lorain, Ohio, will be sales manager.

Lorain Holland has made arrangements with Holland Cranes, an association of Dutch manufacturers, for partial production and final assembly of certain models of "Lorain" line of products as an initial step in this new program. Production will be underway in January, 1957.

Walworth Acquires Grove Firms

Walworth Company has contracted to acquire all the outstanding capital stock of the Grove Valve and Regulator Company and Grove Controls, Inc., both of Oakland, California.

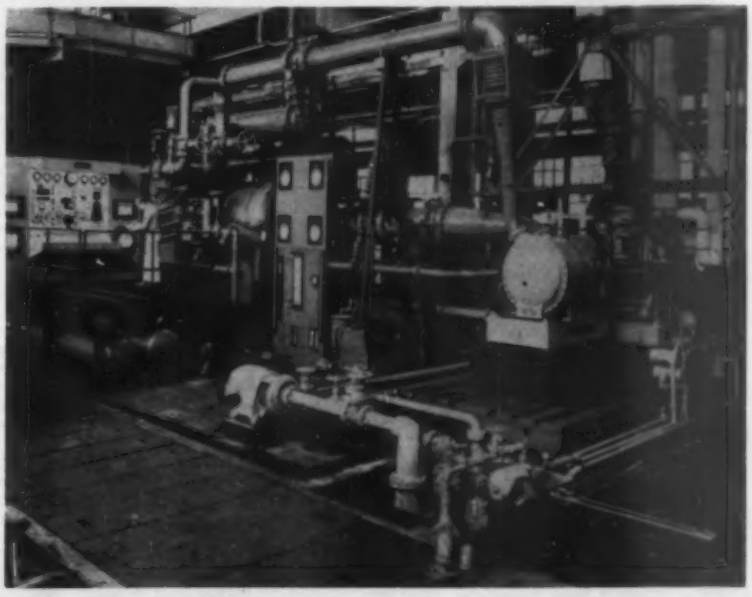
The Grove companies have been engaged in new designs and developments in controls and ultra-high pressure regulators for the gas and oil producing business, and the chemical and petrochemical industries.

A new Longview, Texas, plant of the Grove companies will be made available for Walworth and its subsidiaries.

Lane-Wells Plant Safety Award

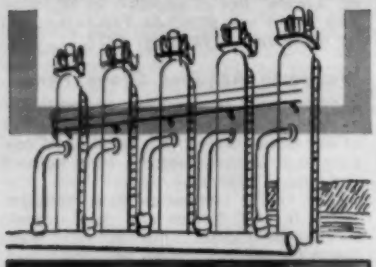
In recognition of over 1,250,000 manhours of safety without a single lost-time accident, the Los Angeles, California plant of Lane-Wells Company, one of the Dresser Industries, has been presented with the Award of Honor of the National Safety Council.

Presentation was made by A. M. Noyes, assistant manager and director of industrial safety for the greater Los Angeles Chapter of the council to John J. Neale, president, and E. A. Miller, works manager of Lane-Wells Company.



Closed-circuit test loop with electronic digital computer, a new research tool, to be used by Worthington Corporation in testing centrifugal refrigeration compressors.

FEWER "TURN-AROUNDS"



Shutdowns for repairs of fire clay linings in refractory units are expensive. The frequency and duration of these shutdowns can be greatly reduced by the use of a steel grating armor known as "Gridsteel", which holds the castable refractory linings in place longer and armors them against the bombardment of catalytic elements.

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Combining their companies' oil well service operations is discussed by John B. Merritt, executive vice president of BJ Service, Inc., and R. G. Miller, executive vice president of Chemical Process Company, as they shake hands on completion of arrangements.

Chemical Process Assets Bought

BJ Service, Inc., and Chemical Process Company, of Breckenridge, Texas, have combined their oil well service operations.

Merger of the two companies was completed under an arrangement whereby all assets of Chemical Process were acquired by the Borg-Warner Corporation. (BJ Service is the oil well service organization in the Byron Jackson Division of Borg-Warner.)

Two major laboratories, at Breckenridge, Texas, and Long Beach, California, will coordinate their development projects on oil well service techniques and new service tools and equipment.

Chemical Process specializes in fracturing, acidizing and permeability meter surveys and operates in Texas, Oklahoma, Louisiana, Kansas, and New Mexico.

Win-Well Sales Representatives

The appointment of Arduster & Company, Tulsa, Oklahoma, and Specialty Sales and Service, Inc., Odessa, Texas, as sales representatives for Win-Well Manufacturing Company has been announced.

Arduster & Company will direct sales in the Oklahoma territory for Win-Well. Specialty Sales and Service will handle the Dallas-Fort Worth and West Texas sales area with headquarters in its Odessa branch.

American Tractor - Case Merger

The boards of directors of the J. I. Case Company and the American Tractor Corporation have approved plans for a merger that would give Case a broad entry into the construction and roadbuilding fields with a line of crawler tractors and earthmoving equipment.

American Tractor is one of the six full-line producers of crawler tractors and equipment in this country. It started manufacturing in 1950, and in the past two years has increased its volume more than 400 per cent.

No major changes in personnel are contemplated except that Marc B. Rojtman will occupy the newly created position of executive vice president and general manager. The merged companies will operate as the J. I. Case Company.

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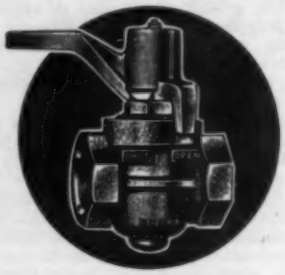

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One Millionth Ton of Steel Pipe

Production of the one millionth ton of oil country steel pipe made in Northeast Texas was celebrated in September by Lone Star Steel Company.

Lone Star turned out its millionth ton of steel pipe a month prior to the ninth anniversary of iron production at the now fully integrated mill.

The two electric weld pipe mills of Lone Star's E. B. Germany Works, part of a $90,000,000 steel division expansion, began operation in February, 1953. Both mills were producing design capacity in November, 1954.

Grants for Higher Education

Educational grants totaling approximately $1,000,000 by The International Nickel Company, Inc., in its program for aid to higher education in the United States, have been announced.

Some $400,000 of these grants will be for the current 1956-57 academic year, with approximately 85 universities and colleges sharing in the grants. The remaining $600,000 will be applied to extending its fellowships and scholarships during the following four years.

PGAC Has Tenth Anniversary

Perforating Guns Atlas Corporation celebrated the tenth anniversary of the founding of the company in October.

Business was started with one employee, in quarters covering only some 500 sq ft. Now the Houston, Texas, plants occupy over 40,000 ft. PGAC serves the oil field in this country, and Canada, Venezuela, and Germany.

Statement Required by the Act of August 24, 1912, as Amended by the Acts of March 3, 1933, and July 2, 1946 (Title 39, United States Code, Section 233) Showing the Ownership, Management, and Circulation of

THE PETROLEUM ENGINEER

Published monthly, semi-monthly in July, at Dallas, Texas, for October 1, 1956.

1. The names and addresses of the publisher, editor, and business managers are:

Publisher: The Petroleum Engineer Publishing Company, 800 Davis Bldg., Dallas, Texas.

Editor-in-Chief: F. H. Love, 800 Davis Bldg., Dallas, Texas.

Business Manager: Joe B. Woods, 800 Davis Bldg., Dallas, Texas.

2. The owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding 1 per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a partnership or other unincorporated firm, its name and address, as well as that of each individual member, must be given.)

American Security Life Insurance Company, Marshall, Texas.

Fidelity National Life Insurance Company, 405 South Akard, Dallas, Texas.

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3. The known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.)

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4. Paragraph 2 and 3 include, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting; also the statements in the two paragraphs show the affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner.

Joe B. Woods, Business Manager.

Sworn to and subscribed before me this 28th day of September, 1956.

(Seal) Lillian H. Johnston
Notary Public, Dallas County.
(My commission expires June 1, 1957.)

Successful test of giant collapsible rubber tanks being completed in an oil field under actual operating conditions. The tanks, designed for oil, water, or other liquids in areas where storage or transportation problems occur, are manufactured by The Firestone Tire & Rubber Company.

This rugged new engine has been added to the Wisconsin line to fill the horsepower gap between the Model VF4 25 hp. and the Model VG4D 36 hp. Wisconsin Engines. At the same time, the mounting base is dimensionally identical to the Models VE4 and VF4 to permit convenient replacement of the latter engines if greater power is required.

The Model VH4, which now makes its bow for the first time, is the most powerful engine of its type and size available today, in our estimation. It is an engine of basic High Torque design which gives it the important advantage of being able to deliver maximum usable *Lugging Power* that carries the load through the hard, heavy pulls. It has been designed to give you the best possible performance at all engine speeds from 1400 to 2800 rpm., even when operating under intermittent shockloads or under constant load, continuous service.

The Model VH4 is a heavy-duty engine in all respects, built for hard service under all operating conditions, at temperatures from sub-zero to 140° F. (60° C.). It is an exceptionally smooth-running, even-firing engine and has all the traditional heavy-duty features that characterize *all* Wisconsin Models, from 3 to 36 hp. It can be supplied as an "open engine" with side-mount fuel tank, or as housed power unit and may be equipped with electric generator and starter (or starter only), clutch, reduction or clutch-reduction assemblies . . . and is adaptable to operation on a variety of fuels such as gasoline, kerosene, natural gas, Butane, Propane or fuel oil of 35 Octane rating or better.

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TRADE PERSONALS

A. K. McCord

▸ **A. King McCord** has been elected president of Westinghouse Air Brake Company.

McCord succeeds **E. O. Boshell,** who has been serving as both chairman of the board and president since joining Westinghouse Air Brake in 1951. McCord has been president since 1950 of the Oliver Corporation, producer of agricultural and construction equipment.

▸ **Charles E. Meginnis** has been appointed as assistant sales manager of the industrial chemicals department of Davison Chemical Company Division of W. R. Grace & Company.

▸ **John Van Riper** has been appointed fracturing supervisor for BJ Service, Inc., to direct the company's expansion into the hydraulic fracturing field.

He was formerly associated with Continental Oil Company.

▸ **Wayne E. Evans** has been named to head General Electric Company's newly established microwave district sales office in Kansas City, Missouri.

▸ **S. E. Gewin** is now district manager of The Bristol Company's Chicago, Illincis, office.

Gewin's successor as manager of the St. Louis, Missouri, office will be **Walter Messner.** Messner has been regional field engineer in Tulsa, Oklahoma.

▸ **David J. Davis** has stepped into the newly created position of general sales manager, construction machinery, for Gar Wood Industries, Inc.

Davis was formerly sales manager for Gar Wood tractor equipment sales.

▸ **W. C. (Hut) Erwin** has been appointed general manager of Canadian operations for S. R. Bowen Company.

Erwin recently has served as the western division general manager in charge of operations in the West Coast, Rocky Mountain, and Canadian operations of another fishing tool service organization.

Jack Gary

W. C. Irwin

▸ **Jack Gary** has been appointed as Fluid Packed Pump Company's Latin-American representative. Prior to his present assignment, Gary spent the past two years in the Gulf Coast division of Fluid Packed Pump. In his new capacity, he will make his headquarters at Maracaibo, Venezuela.

▸ **Marlin R. Hemphill** has been appointed general manager of the forging and casting division of Allegheny Ludlum Steel Corporation in Ferndale, Michigan.

Hemphill is now general manager of the Carmet division at Ferndale, and will retain his existing position along with his new duties. **T. A. Moormann,** who was plant manager at Ferndale, died this summer.

P. J. Moore

R. W. Wilson

C. J. Benefiel

R. E. Souther

▸ Numerous promotions and transfers in six departments of Baroid Division, National Lead Company, have been announced.

R. W. Wilson has been named assistant manager, technical sales and operations. Wilson was formerly manager of the well logging department. **R. E. Souther** has been appointed to Wilson's former position. Souther was formerly manager of the Houston, Texas, equipment department.. **P. J. Moore** succeeds Souther. Moore was formerly a sales engineer in the equipment department.

C. J. Benefiel, former transportation superintendent of Mud Products, Inc., at Tulsa, Oklahoma, is now manager of Baroid's transportation department, with headquarters in Houston.

W. G. Bealmear, S. E. Geffen and **J. W. Maltby,** former district superintendents in Corpus Christi and Fort Worth, Texas, and New Orleans, Louisiana, respectively, have been appointed area superintendents of well logging in Southwest Texas, Mid-Continent, and eastern Gulf Coast areas.

A. B. Lane has been named well logging district superintendent in Southwest Louisiana at Lafayette. He was formerly assistant district superintendent.

R. E. Haley, well logging district superintendent, has been transferred from Shreveport, Louisiana to Oklahoma City, Oklahoma. **D. B. Reeves,** formerly well logging assistant district superintendent in Liberal, Kansas, is now district superintendent in Kansas and the panhandle sections of Texas and Oklahoma.

V. R. Kayser has been made well logging district superintendent in Southwest Texas with headquarters in Corpus Christi. He was formerly a well logging captain.

▸ **W. J. Klein** has been appointed vice president and director of sales and **W. L. Voegeli** general sales manager, tractor

W. L. Voegeli

W. J. Klein

group, Allis-Chalmers Manufacturing Company.

Klein has been vice president and general sales manager, tractor group, while Voegeli has been assistant director of engineering.

▸ **Dr. Franklin E. Lowance** has been elected vice president of research and engineering for Union Switch & Signal Division of Westinghouse Air Brake Company. He has been director of research and engineering.

▸ **Frank J. Curley** has been promoted to vice president and resident manager and **John E. Bruce** to service manager for

F. J. Curley

J. E. Bruce

Johnston Testers, Ltd.

Curley formerly was sales manager for the company and Bruce was district manager in Regina, Saskatchewan, Canada.

▸ **John P. Jennings** is now general sales manager of Chicago Steel Tank Company, coming from the Nooter Corporation

▸ **Fred Niemeier** has been named general manager of the Petroleum Specialty Company, Pampa, Texas. He was formerly Rocky Mountain division and western Canada sales manager for the firm, working out of Casper, Wyoming.

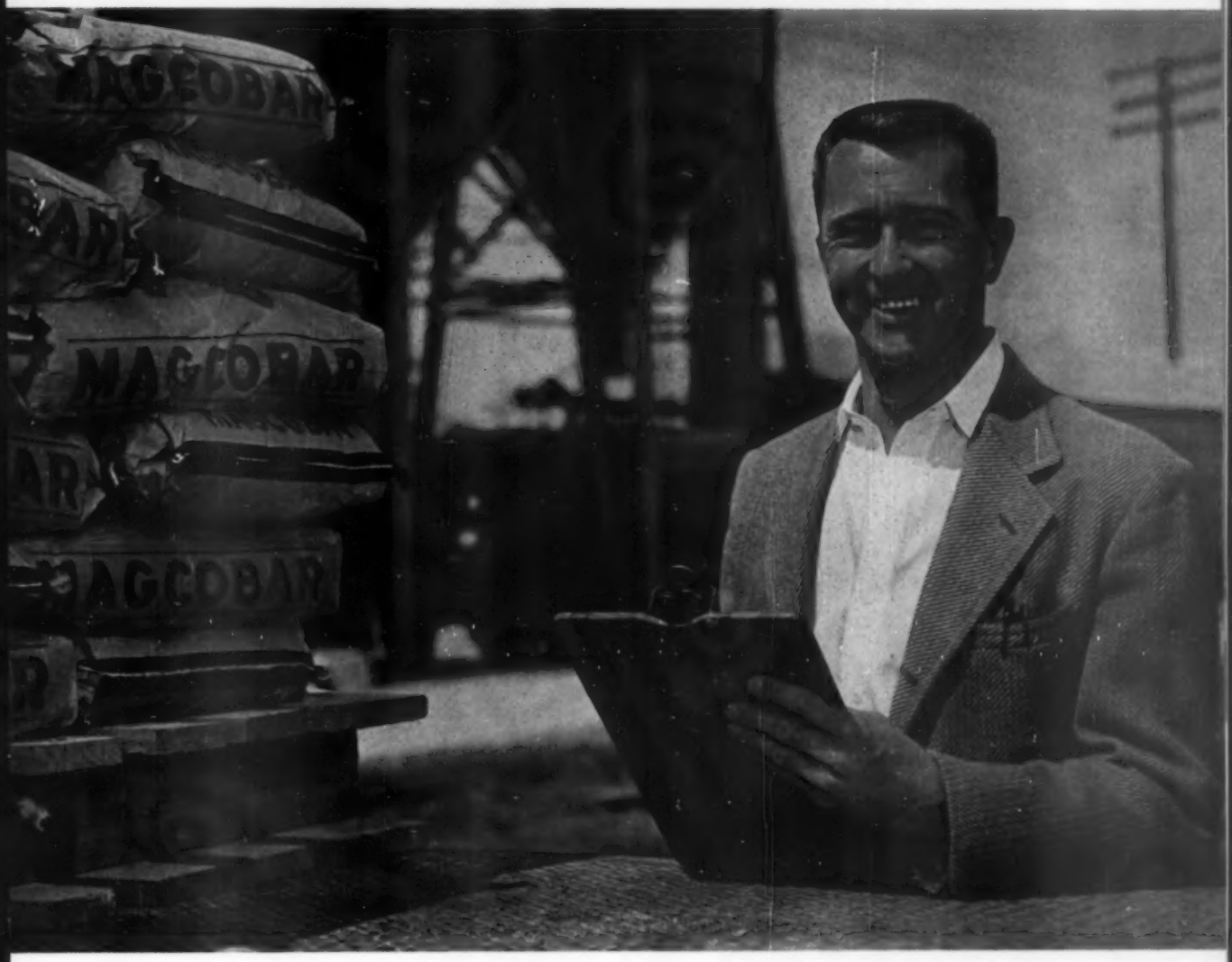
Fred Niemeier

M. A. Hammond

▸ **Millard A. Hammond** has been named manager of welding fittings sales of The Babcock & Wilcock Company, tubular products division, with headquarters at Milwaukee, Wisconsin.

Hammond was formerly in charge of fittings sales in the division's Philadelphia, Pennsylvania district.

It takes a complete team to keep dependable drilling mud service available for you.



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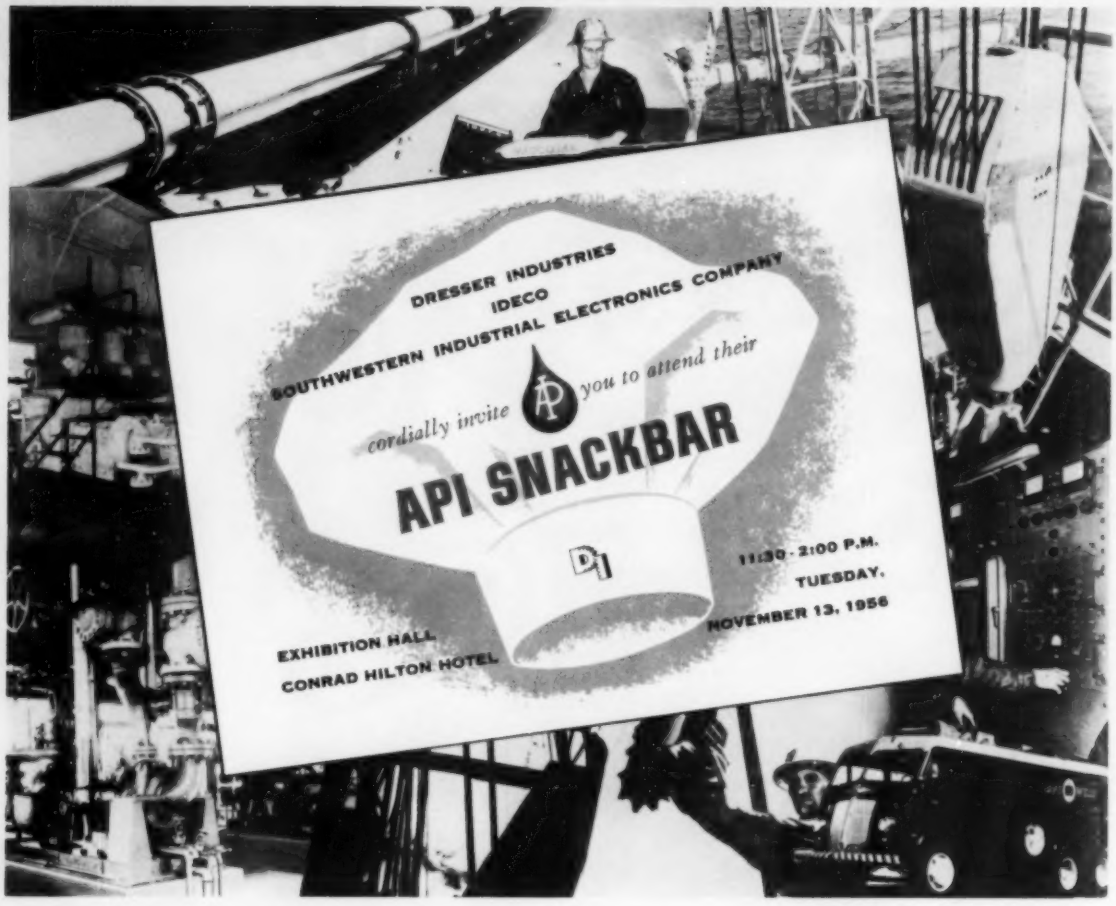
Complete
DRILLING MUD SERVICE

MAGNET COVE BARIUM CORPORATION

Houston, Texas



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CLARK BROS. CO., Olean, New York —Gas turbines, engines, and reciprocating, centrifugal and axial flow compressors—gas, steam, electric and diesel driven.

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DRESSER-IDECO COMPANY, Columbus, Ohio—Radio and television broadcasting towers, steel buildings, aircraft hangars, electric power substations.

DRESSER MANUFACTURING DIVISION

DRESSER MANUFACTURING DIVISION, Bradford, Pa.—Pipe line couplings, pipe repair sleeves and clamps, weldments, forgings, welding fittings, flanges, rings.

IDECO®

IDECO, Dallas, Tex.—Hydrair* and Power Rigs; Full-View* Masts; substructures; single, dual and Drive-In Rambler Rigs; blocks, swivels, rotaries; mud pumps; petroleum equipment and supplies.

LANE WELLS

LANE-WELLS CO., Los Angeles, Calif., Houston, Tex., Oklahoma City, Okla.—Electric and Radioactivity Well Logging, Koneshot* perforating and bullet perforating, bridging plugs.

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MAGNET COVE BARIUM CORP., Houston, Tex.—Magcobar* and Magcogel* drilling muds and other specialized oil well drilling fluids and chemicals.

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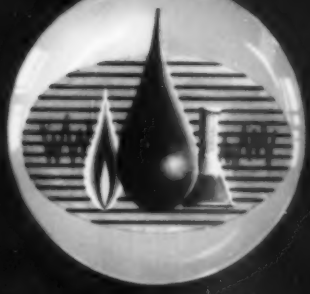
PACIFIC PUMPS, INC., Huntington Park, Calif.—Centrifugal pumps for refineries, power stations, pipelines, and chemical plants; plunger pumps for oilwells.

ROOTS-CONNERSVILLE

ROOTS-CONNERSVILLE BLOWER DIVISION, Connersville, Ind.—Rotary positive blowers, gas pumps, centrifugal blowers, exhausters, vacuum pumps, and positive displacement meters.



Security

SECURITY ENGINEERING DIVISION, Dallas, Tex., Whittier, Calif.—Rock bits, reamer rock bits and hole openers, reamers, casing scrapers and Neo-Red rubber stabilizers.

SIE

SOUTHWESTERN INDUSTRIAL ELECTRONICS CO., Houston, Tex.—Seismograph systems and instruments—electronic, electro-mechanical. Computers—analog and digital; recording systems. Special transformers, reactors.

GUIBERSON

GUIBERSON CORPORATION, Dallas, Tex.—Oil tools: packers, anchors, workover equipment — drilling heads, blowout preventers, tubing blocks, hooks, swivels, kellys, savers, unions. Gas lift equipment. Molded rubber products.

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You receive a bonus of extra value whenever you are served by any one of the Dresser companies. Each Dresser operating unit provides the research, engineering, manufacturing and service applications for its particular specialties. *All* work together to provide the combined experience and facilities of the world-wide Dresser industrial team. This inter-company teamwork offers a bonus in greater experience and technical knowledge – backed by the extensive Dresser facilities – in the customer's specific industry. This intangible but important factor is known throughout the world as the Dresser plus + . . . the mark of superior equipment and services for the oil, gas, chemical, electronic, and general industry.

Dresser's world-wide engineering experience in many industries plays a major role in the creation of new developments and improved technological methods. No other single company provides the same broad range of equipment and services. The Dresser plus + is a symbol for the superior quality of equipment and technical services which have become the standard of comparison in industries the world over!

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ALL NEW DESIGN!

Simple...Foolproof...Low Cost

1500 WATT HOMELITE GENERATOR

Model 35A115
Homelite Generator
1500 Watts, 115 Volt
60 Cycle AC
90 lbs.

As easy to move as an electric hand saw!

1. New Money-Saving features . . . No DC brushes; just two easy-to-get-at collector ring brushes . . . No commutator or DC windings . . . No intermediate couplings; armature keys directly to shaft. Fewer parts to wear out — longer trouble-free generator service.

2. Constant Voltage . . . less than 4% change from no load to full 1500 capacity . . . assures long service life for your electric tools . . . guarantees top performance at all times.

3. Overload Capacity . . . 1500 watt continuous duty with generous overload capacity prevents tool stalling under heavy loads . . . insures uninterrupted service even when starting loads exceed operating loads.

4. Compact and Lightweight . . . one man can easily carry this generator wherever you need electricity to power time-saving electric tools. No need for long, hazardous power-consuming cables.

Whatever tools you want to operate — electric saws, drills, floodlights, grinders, belt sanders, hammers — the new Homelight 35A115 generator can save you money. For a free demonstration or additional information, call your nearest Homelite representative, or write:

SAVE EVEN MORE! New Homelite electronic idle control unit, available as optional accessory, runs engine at idle speed when no current is drawn . . . automatically brings engine to full speed when load is applied.

Ask your Homelite representative show you how this easily-installed Ask your Homelite representative to accessory reduces engine wear . . . increases service life . . . cuts fuel consumption.

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A DIVISION OF TEXTRON, INC.
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Manufacturers of Carryable PUMPS • GENERATORS • BLOWERS • CHAIN SAWS

Full Line of Carryable Construction Equipment Now Offered by Homelite

Carryable Diaphragm Pump . . . This self-priming, 120 pound diaphragm pump will handle water in the thickest sand, muck, or mud. Capacity: 5,000 g.p.h. Size: 3". Complete line of centrifugal pumps are also available in sizes from 1½" to 3".

Chain Saws For Every Job . . . Now you can choose from a full line of lightweight, powerful Homelite chain saws. From 3½ to 7 horsepower . . . 19 to 29 pounds. Brush cutting and clearing attachments are available to handle all your cutting jobs.

One-Man Electric Vibrator . . . It takes only one man to place concrete with powerful, Homelite high-cycle or universal electric concrete vibrators. Carryable Homelite generator provides power for high-cycle vibrators *and* 110 volt DC for all universal vibrators, tools and floodlights.

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Trade Personals

▸ Reed Roller Bit Company has announced the promotion of three men to vice presidencies in the firm.

C. H. Elliott, former manager of the Cleco air tool division, was named vice president of that division. At the oil tool divison, **H. B. Book,** former export sales division manager, was made vice president, sales, and **J. A. Grundy,** former factory manager, was appointed vice president, manufacturing.

▸ **Col. Willard F. Rockwell,** board chairman of Rockwell Manufacturing Company and Rockwell Spring & Axle Company, has been knighted by the Italian government in the order "Al Merito Della Repubblica."

The honor — usually reserved for Italian citizens — was conferred by Vice Consul Carlo M. Rossi-Arnaud on behalf of the president of Italy.

Dr. Rossi cited Colonel Rockwell's "outstanding contributions to Italy's reconstruction and economic recovery since World War II, and his inspired efforts to promote closer economic relations between this nation and the United States."

▸ **George Bush** has been promoted to sales division manager of the south central sales division of Cleco Air Tool Division of Reed Roller Bit Company.

Bush replaces **E. W. Clayton,** who has been promoted to manager of sales development for Cleco.

▸ **L. H. Ingle** has been elected treasurer of Lane-Wells Company, where he has been controller.

Robert L. Walsh has been advanced from chief accountant to assistant controller. **F. E. Miller** replaces Walsh as chief accountant.

Robert Lee Alder, research supervisor, has been made research manager, with headquarters at San Gabriel, California. Replacing Alder is **Dr. A. L. Floyd,** who will have technical supervision of the research projects.

▸ **R. A. Winsryg** has been appointed regional manager of the Los Angeles, California, region for Byron Jackson Pumps, Inc. He previously served as manager of the Houston, Texas, region.

E. L. Lindsey has taken over as regional manager of the Houston area. He formerly held the position of Los Angeles regional manager.

▸ **John Sukup** has been named to the newly created post of industrial relations director for Security Engineering Division, one of the Dresser Industries.

Sukup comes to Security from National Gypsum Company at Parsons, Kansas, where he occupied a similar position.

▸ Several personnel changes in the field sales organization of Parkersburg Rig and Reel Company have been announced.

J. W. Robbins, formerly manager of the Gulf Coast — Mexico division, has been promoted and transferred from Houston to Fort Worth, Texas, as manager of the oil field sales department.

W. J. Slaughter, formerly manager of the Rocky Mountain division, has been promoted and transferred from Denver, Colorado, to Fort Worth as manager of the pumping unit division. **C. D. Haehl Jr.,** formerly area salesman, has been promoted and appointed manager of the pressure vessel division.

Check these features

Philadelphia spiral-bevel COOLING TOWER DRIVE

- √ Maximum Efficiency . . . 97%-98% with minimum heat loss.
- √ Precision generated Spiral-Bevel Gears, case hardened for long service life.
- √ Heavy duty Housing construction.
- √ High dome permits mounting fan directly on unit, with ample clearance below fan blades.
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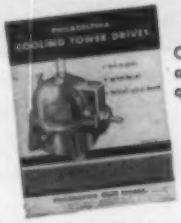
- √ Rugged . . . dependable . . . economical Reducer meets all AGMA standards.

These widely used Drives are made in six sizes, rated from 15 hp to 75 hp at 1750 rpm motor speed, with Ratios ranging from 2:1 to 9.2:1.



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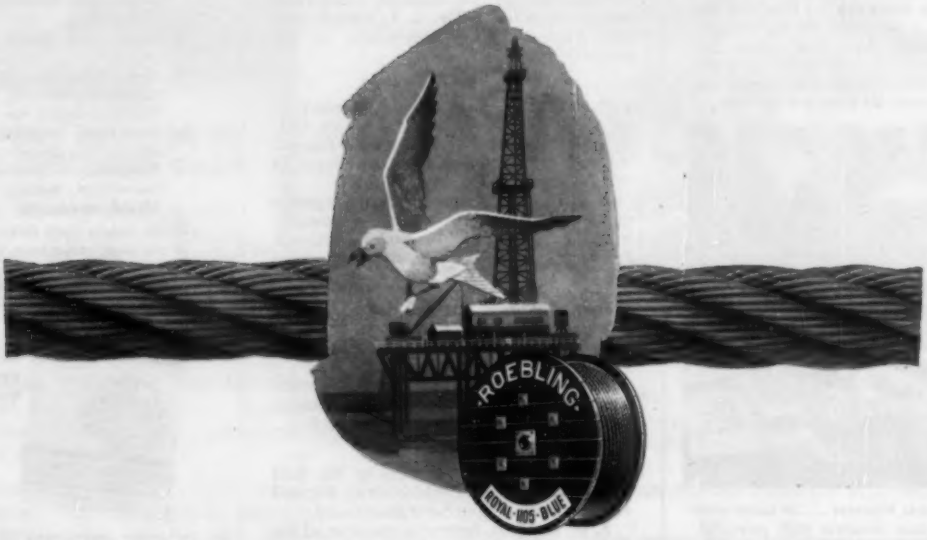
Roebling's finest!

Royal Blue's extra strength vastly increases...even doubles... wire rope service life



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exhaustive tests prove:

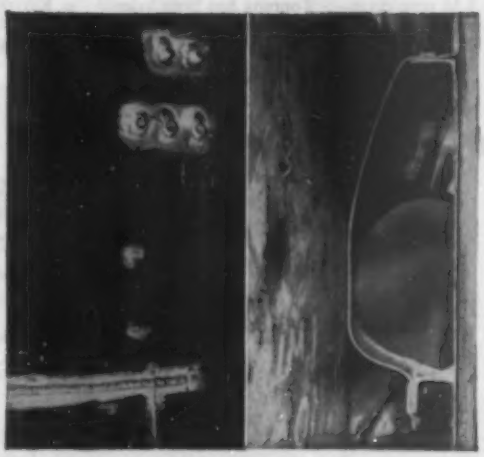
36 YEARS FROM TODAY

TUBESEALS* NOW IN FLOATING ROOF TANKS WILL OPERATE AS EFFICIENTLY AS THEY DO TODAY!

WE DOUBT this can be claimed for any other floating roof seal!

To determine the efficient life-expectancy of the Hammond Tubeseal in service, tests were made under the worst possible conditions to which a floating roof seal can be subjected. The Tubeseal was moved across very rough rivet heads, erection burrs and abrasive weld surfaces, for a total travel of 70,000 feet. This is equivalent to a normal wear of *more than 36 years in actual service.* Moreover, as the tests were run dry, there was the added disadvantage of the absence of lubricating effect normally created by wetted surfaces. Upon completion of these rigorous tests, the scuff band had only worn through the ribs and had barely penetrated through the material, leaving two-thirds of the stock intact; proof that the Tubeseal is unimpaired after traveling 70,000 feet.

The 36 year life-expectancy of a Hammond Tubeseal assumes no mechanical accident and is arrived at in the following manner: Each year a floating roof, in normal service, makes about 48 trips to and from top and bottom of tank. The roof of a 40 foot tank, therefore, will travel 1920 feet per year. Assuming 1920 feet of travel per year (based upon full depth of travel) and applying our accelerated wear test, the Tubeseal will be serviceable for at least 36 years 5½ months.



THE TUBESEAL TEST:

total travel	70,000 feet
travel over vertical weld	46,400 feet (on same line)
Horizontal welded seam crossed	21,200 times
Flat head rivets crossed	63,600 times

CONDITION OF TUBESEAL AFTER TEST: Scuff band had worn through ribs and had barely penetrated into the main material, leaving ⅔ of stock intact.

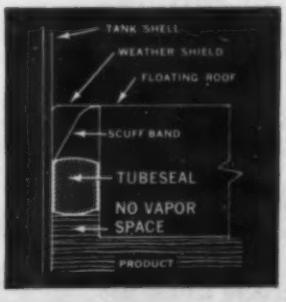
Tests were conducted dry with no aid of lubricant normally resulting from stored product.

Photos show projections used for test. Included are 16" of ⅜" horizontal weld—24" of sharp, irregular vertical weld—2 erection burrs—3 ¼" flat head rivets and 2 ¾" cone head rivets.

THE HAMMOND TUBESEAL
is the most efficient and positive seal known.

it features:

no moving parts
no mechanical maintenance
climate proof
non-corrodible
can operate to bottom of tank or above the top
no vapor space below the seal
entire circumference has tight seal under pressure at all times
longer working life expectancy



NO ROOM FOR VAPORS
NO EVAPORATION
NO CORROSION

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Trade Personals

▸ **Lawrence T. Peifer,** manager of business development for Borg-Warner Corporation, has been appointed administrative vice president of the corporation's Atkins saw division in Indianapolis, Indiana.

▸ **James G. Walker** has been appointed northeastern regional sales manager for Johns-Manville Corporation's pipe division. Walker succeeds **Charles T. Dearborn,** who retires after a 39-year career with Johns-Manville. The northeastern regional sales office was recently transferred to New York City from Boston, Massachusetts.

Charles G. Topping succeeds Walker as New York area sales manager for the J-M pipe division. Topping has been sales representative for the division in upstate New York at Rochester.

▸ **Eugene K. Kelly** has been appointed works manager of the Detroit Diesel Engine Division of General Motors Corporation. In his new post, Kelly succeeds **Clyde W. Truxell,** whose appointment as general manager was also recently announced.

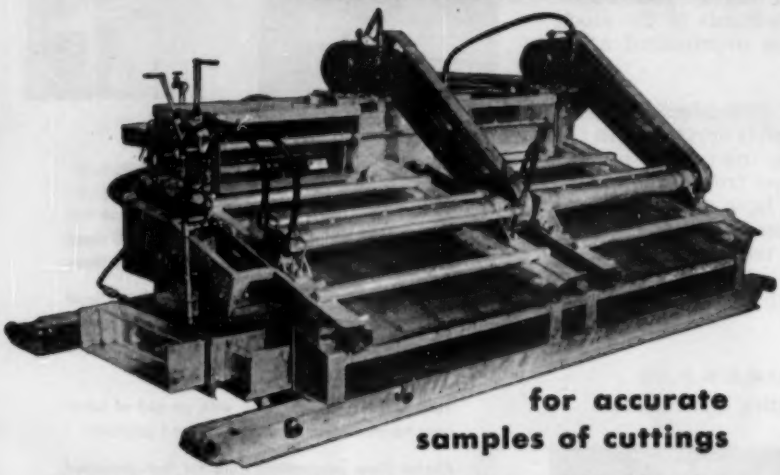
Prior to his present appointment, Kelly served as master mechanic of aircraft engine operations at GM's Allison Division in Indianapolis, Indiana.

▸ **Tom E. Remp Jr.** has been promoted to headquarters area and export sales manager for Weatherford Oil Tool Company. He succeeds **Robert Hume,** who has been placed on a special foreign assignment for management.

Remp has been a sales and field service man for Weatherford in the Houston, Texas, area.

Thompson

DOUBLE VIBRATING SHALE SHAKER...and SAMPLE MACHINE



for accurate samples of cuttings

The THOMPSON SHALE SHAKER SAMPLE MACHINE offers the operator and geologist one of the best methods available for obtaining accurate foot-by-foot samples of well cuttings.

This THOMPSON DOUBLE VIBRATING SHALE SHAKER and SAMPLE MACHINE is specially engineered for off-shore barges or islands, deep wells, or wells using big volume and high pressure mud pumps. It is available either plain or galvanized, which makes it rust and deterioration-proof on off-shore or coastal duty

THOMPSON Shakers are famous for their highly efficient service at any depth or flow and for their economical first cost.

Make sure THOMPSON'S on the job for accurate samples and clean mud.

SOLD ONLY THROUGH SUPPLY STORES

Thompson TOOL CO. IOWA PARK TEXAS

▸ A new corporation, Applied Power Equipment & Manufacturing Company, has been formed by former officials of Buda Engine and Equipment Company, Inc., (subsidiary of Allis-Chalmers Manufacturing Company) to take over exclusive distribution of Allis-Chalmers and Buda engines in South Texas. Main office is in Houston.

Officers of the new corporation are **John Munro,** president; **Thomas J. Howard,** vice president and sales manager; **A. H. Benson,** general service manager, and **W. C. Dvorak,** secretary-treasurer.

▸ **Philias H. Girouard,** chief engineer, U. S. Navy Bureau of Ordnance, has been appointed assistant director of engineering for Consolidated Electrodynamics Corporation.

▸ A change in organization structure has been announced by Chain Belt Company, with the establishment of two sections — an industrial equipment section and a construction machinery section.

W. J. Sparling, now vice president in charge of Milwaukee operations, will become vice president — manufacturing and industrial equipment, and will have executive responsibility for those divisions making up the industrial equipment section. **O. W. Carpenter,** vice president of finance, will be vice president — construction machinery and finance. He will have executive responsibility for those divisions making up the construction machinery section.

E. M. Rhodes, divisional manager of the firm's eastern operations, will be located in Milwaukee, Wisconsin, and will fill the newly created position of manager of chain operations. **J. D. Sloan,** assistant manager, roller chain division, will succeed Rhodes as manager of that division.

A. K. Thomas, present manager of the construction machinery division, will become assistant to the vice president of the construction machinery section. **W. C. Messinger,** sales manager of the construcion machinery division, will become manager of that division. **J. W. Lendved,** director of engineering for the construction machinery division, will also serve as director of product development for that division.

▸ **Robert M. Hatfield,** vice president of Combustion Engineering, Inc., has been appointed general sales manager of the company. Hatfield formerly was vice president of the western division with headquarters in Los Angeles, California.

Frank M. Bader, now an assistant general sales manager in New York, will succeed Hatfield.

▸ Recent changes have been announced by The American Iron and Machine Works Company sales department

F. E. Wagner has been appointed regional manager for California, the Rocky Mountains, Kansas, Oklahoma, Illinois, and Eastern Canada. His headquarters will remain in Oklahoma City, Oklahoma.

Joe Thompson's new position is regional manager for West Texas, North Texas, Texas Gulf Coast, Ark-La-Tex, and the Louisiana Gulf Coast, having formerly been on the sales force in the Kansas district. His headquarters will be in Houston, Texas.

The new district manager of the Oklahoma district is **B. E. Sharp,** who had held a sales position in the district and will continue to live in Oklahoma City. He succeeds Wagner.

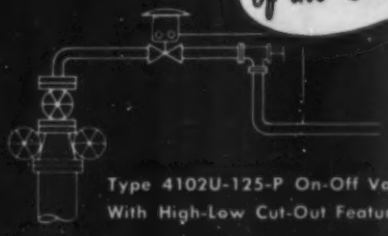
FISHER®

Hi-Low Cutout Controllers

The Sentinel of the Field

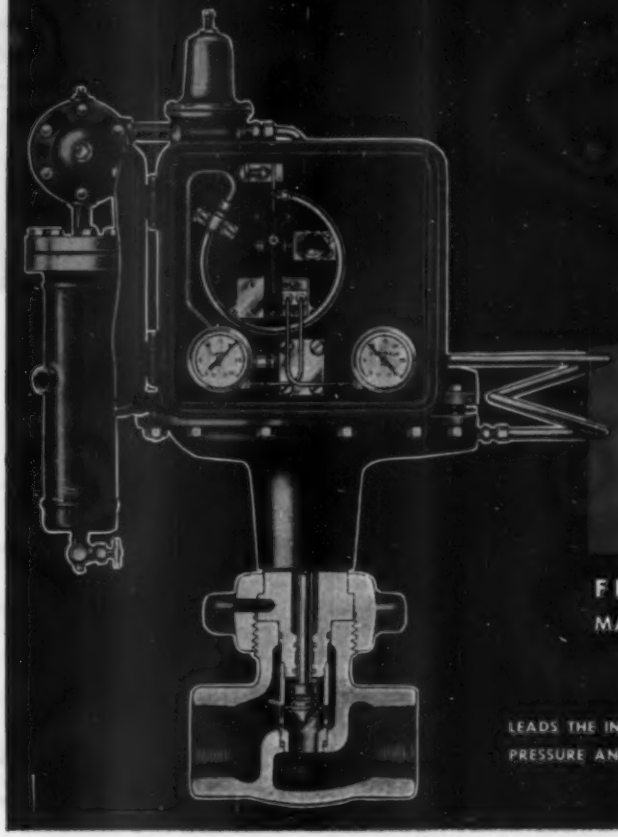
Type 4102UR-125-P Field Valve With Low Pressure Cut-out Feature

Always on guard, the Fisher Type 4102UR pilot when installed in gathering lines will throttle or reduce the pressure to separators and will automatically close if a break in the line occurs, thus protecting the system from costly loss.



Type 4102U-125-P On-Off Valve With High-Low Cut-Out Feature

Ideal as a high-low-pressure well head shuts valve. Will stay open, but will automatically close if pressure goes above pressure limitations of downstream piping. Will also close if pressures fall too low *due to* a break in downstream system.



- Wizard available with bronze or steel Bourdon tubes up to 5000 psi.
- Rugged and compact—entire controller not over 2 feet high.
- Series 125-P field valve supplied with heavy cast steel body good for 2000 psi.
- Topwork action reversible in field with no additional parts.

SPECIFICATIONS

Body—Cast Steel—2000 psi WOG.
Sizes—1" and 2" screwed angle or globe.

Valve Caps—440 hardened St. Steel. (Stellite carbide insert also available.)

Orifice Sizes—1" Body—¼", ⅜", ½", ¾". 2" Body—½", ¾", 1", 1½", 1".

Inner Valves—440 hardened St. Steel. (Stellite carbide tip also available.)

FISHER GOVERNOR COMPANY
MARSHALLTOWN, IOWA • WOODSTOCK, ONTARIO

LEADS THE INDUSTRY IN RESEARCH FOR BETTER PRESSURE AND LIQUID LEVEL CONTROL

FISHER *Since 1880*

NOW new E-M Packaged

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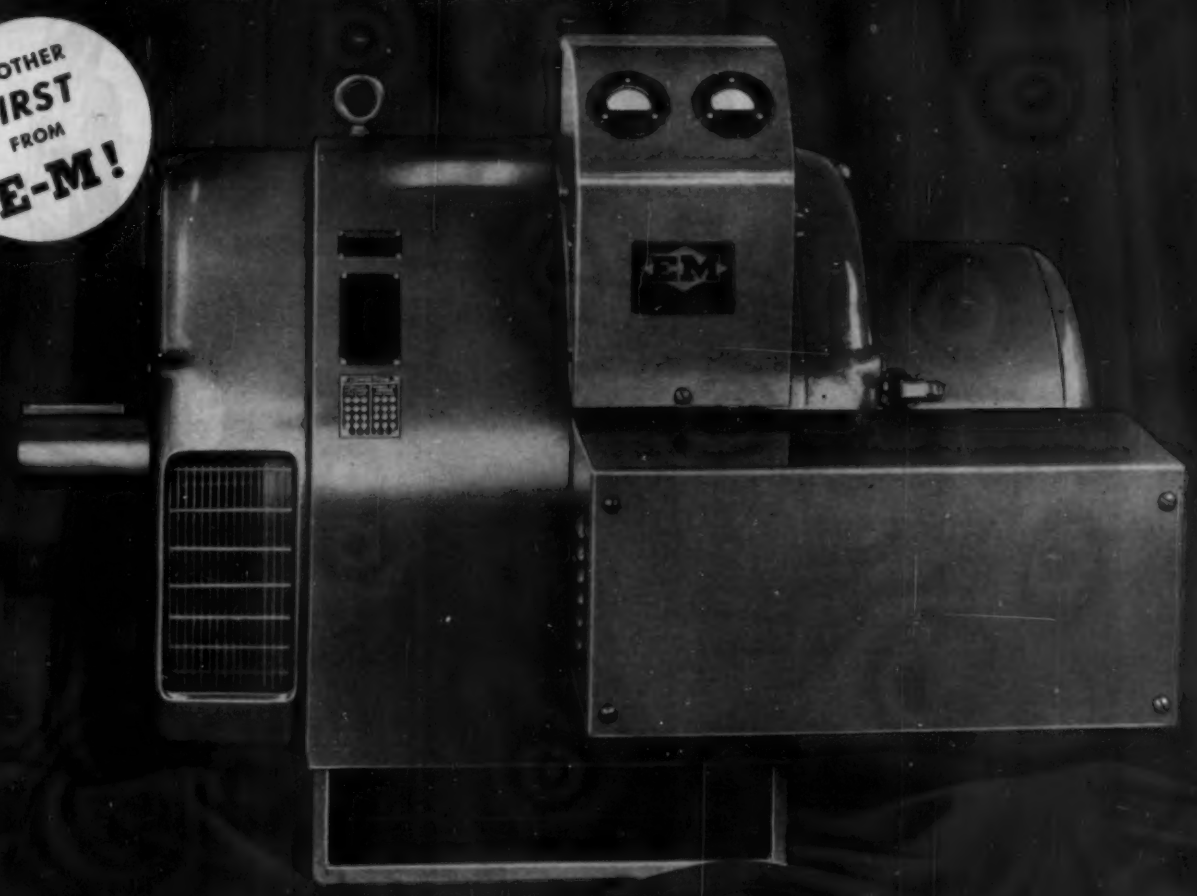


Why this *new* AMP-PAK Packaged Generator?...10 BIG ADVANTAGES FOR YOU

1 **LICKS THE MAINTENANCE PROBLEM** — no moving parts in the excitation or regulation systems . . . no tubes, no rotating parts, no vibrating contacts.

2 **SIMPLE OPERATION** — no belts, no "tricky" commutator, no adjustments — anyone can operate AMP-PAK.

3 **MAGNETIC AMPLIFIER "MAGIC"** — regulates voltage — unique voltage sensing circuit keeps voltage "on the beam".

4 **"ROCK-STEADY" VOLTAGE** — makes your motors, lights, and electronic equipment work better.

5 **STARTS BIG MOTORS** — built-in voltage booster transformer leaps into action to maintain voltage level!

6 **POSITIVE VOLTAGE CONTROL** — easily set to compensate for line voltage drop.

7 **NEW, HEAVY-DUTY FRAME** — keeps AMP-PAK's interior safe, clean, and dry.

8 **SIMPLE INSTALLATION** — AMP-PAK is self-contained and factory assembled. Large, one-piece foot simplifies alignment . . . is universally adaptable to mounting requirements.

9 **NEW, EASY-TO-READ METERS** — no need to stoop. Each meter floats in a ring of live rubber.

10 **TOP QUALITY PERFORMANCE** is built into every AMP-PAK. Backed by more than 50 years' engineering experience of the country's largest manufacturer of Packaged Generators.

Generator: AMP-PAK...

HAS NO REVOLVING EXCITER, NO MOVING PARTS IN THE VOLTAGE REGULATOR!

Ratings — 75 thru 187 kva at 1800 rpm and 62½ thru 187 kva at 1200 rpm
3 phase; 80% PF; 60 cycles; 50 C rise
120/208, 240, 480, and 600 volts

Completely New DESIGN TO GIVE YOU...

a compact, revolving field A-C Generator with built-in static excitation system; static voltage regulator; and basic metering and controls conveniently grouped. AMP-PAK is a portable unit – factory assembled, internally connected, and tested. It features:

1. SIMPLIFIED EXCITATION SYSTEM — a heavy-duty, long-life static rectifier and magnetic amplifier replace the old-fashioned type exciter with its commutator, brushes, and rotating parts.

2. RELIABLE VOLTAGE REGULATOR — requires no attention or adjustment. You simply select output voltage (within generator rating) and the regulator keeps the voltage within ±2% of the initial setting.

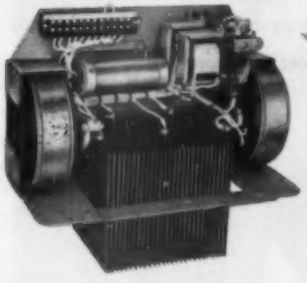
3. VOLTAGE BOOSTER TRANSFORMER — stands by with high speed, reserve power to instantly bolster line voltage by "field forcing" when heavy loads are suddenly applied.

4. PRACTICALLY MAINTENANCE-FREE SERVICE — no vacuum tubes, no vibrating contacts . . . in fact, no moving parts in the entire excitation and regulation systems. The control requires only occasional inspection for general cleanliness.

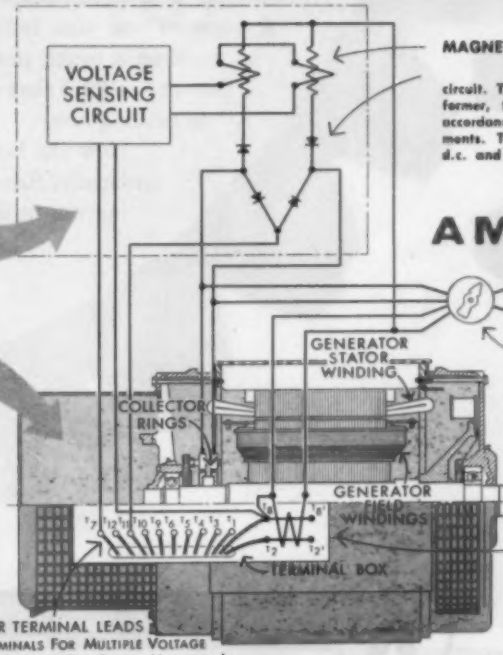
5. SIMPLE OPERATION WITHOUT SWITCHBOARD — you simply connect the load to the Generator thru a suitable line switch.

HERE'S HOW AMP-PAK WORKS

UNIQUE VOLTAGE SENSING CIRCUIT
Provides a continuous and instantaneous comparison between AMP-PAK's output voltage and the built-in reference voltage. Any discrepancy between the two is immediately signaled to the magnetic amplifiers and corrected.



EXCITATION-REGULATOR UNIT WITH ALL STATIC COMPONENTS
Compact, "unitized" construction on rugged saddle, simply removed for access to Generator. Enclosed in dripproof housing in direct path of Generator ventilating air stream for optimum cooling.



MAGNETC AMPLIFIER-RECTIFIER EXCITATION
amplify signals from the voltage sensing circuit. Then, together with the voltage booster transformer, they supply a-c power to the rectifier in accordance with the Generator output voltage requirements. The power rectifier, in turn, converts a.c. to d.c. and energizes the Generator field windings.

12-VOLT SOURCE FROM ENGINE STARTING BATTERY

VOLTAGE BUILD-UP SWITCH
Provides a convenient means of "priming" the Generator field during starting with a momentary "shot" of d.c. from the engine battery. The Generator action then immediately becomes self-exciting.

VOLTAGE BOOSTER TRANSFORMER
Has a dual function in excitation and voltage regulation. Transformer output supplies part of excitation power and introduces field forcing for improved voltage regulation under increased load.

GENERATOR TERMINAL LEADS
(TYPICAL ARRANGEMENT SHOWN–12 TERMINALS FOR MULTIPLE VOLTAGE CONNECTIONS...FEWER TERMINALS MAY BE USED FOR SINGLE VOLTAGES.)

Got a generator problem? SEE YOUR NEAREST E-M SALES ENGINEER, OR WRITE THE FACTORY FOR "CUSTOMIZED" APPLICATION SERVICE.

Originators OF THE "PACKAGED" LINE OF A-C GENERATORS

ELECTRIC MACHINERY MFG. COMPANY
Minneapolis 13, Minnesota

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needed, some way to cool off hot-tempered worms!

AFTER the worms were heated and quenched, their threads were not uniform. Distortion had already destroyed the precision machining so vital for efficient operation and long life.

Technicians traced the trouble back to the tempering process. The soft steel had hardened unevenly and warped. The result: crooked worms with uneven tempers.

This is what Texaco did about it . . .

Available quenching fluids were not doing the job. A superior one was indicated. So — Texaco went to work on a tough problem — came up with the answer — a fluid that equalized metal tempering as never before.

Now the hot steel could be quenched uniformly. Result: true and smooth-turning worms with even tempers!

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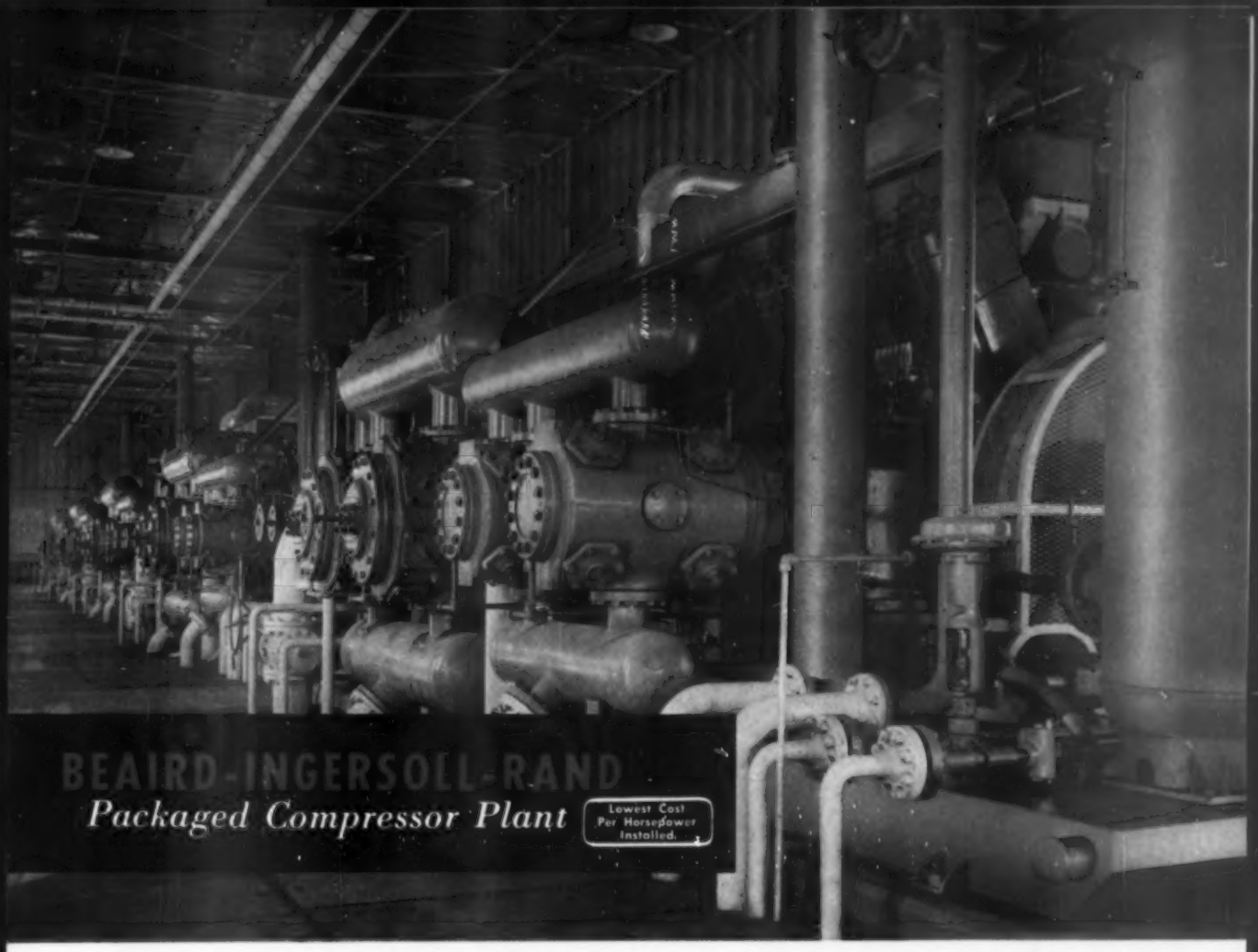

NATURAL GAS PIPELINE COMPANY OF AMERICA'S QUINDUNO STATION—equipped with five Beaird-Ingersoll-Rand 12SVG 660 h.p. packaged compressors. Young radiators with lubricating oil coolers, gas interstage and after coolers and all necessary controls. Other sizes 110 to 660 h.p.

Packaged Compressors Handle —

CRITICAL SOUR GAS PRODUCTION PROBLEM

3300 packaged compressor horsepower is used in the Natural Gas Pipeline Company of America's Quinduno Field station to boost sour casinghead gas through a desulphurization plant and into transmission lines. Providing this horsepower are five Beaird-Ingersoll-Rand 12SVG 660-h.p. units. Gas engineered for the job, the units are equipped with stainless steel compressor piston rods and special rings. Engine radiators which contain gas interstage and aftercooling sections, have been constructed with admiralty metal tubes and aluminum fins. All compressor fittings and scrubber elements have been built from non-corrosive materials.

Capable of handling up to 25 mmcfd, the units pick up at 19 psig and use two stages to boost the gas to transmission line pressure of 260 psig.

Packaged compressors were selected by Natural Gas Pipeline because of the savings that could be achieved in installation time and labor. Also should the gas volume drop off, one or more plants could be moved as complete units to other service. The remaining units would then economically continue production throughout the life of the field. Each of the units when finally taken out of this service, and moved to another, will be almost wholly salvaged.

Let us show you how a Beaird-Ingersoll-Rand packaged compressor plant can be designed to meet your special operating requirements.

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THE J. B. BEAIRD COMPANY, INC.

PACKAGED COMPRESSOR PLANTS

CAST STEEL FITTINGS

PRESSURE BULK STORAGE

ANHYDROUS AMMONIA EQUIPMENT

LP-GAS SYSTEMS

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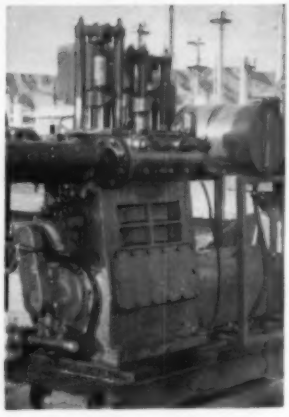
A copy of our new condensed catalog, showing the line of Aldrich Pumps is yours for the asking. Write for Data Sheet 100. The Aldrich Pump Company, 26 Pine Street, Allentown, Pa.



Shown above is one of a number of Aldrich 5" stroke, Triplex Pumps installed at a major west coast water injection project. These pumps are currently handling 35,000 bbl daily at injection pressures of 1,000 psi.

THE

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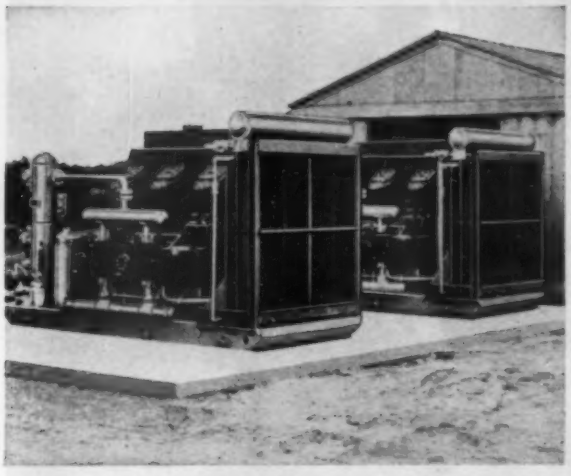
cool compressor plant engines

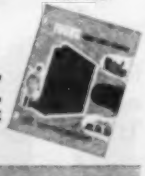


Young jacket water coolers on Beaird-Ingersoll-Rand Packaged Compressors at the Cotton Valley Operators Committee's Justiss Reservoir's Pressure Maintenance Station.

Young *Mono-Weld*® jacket water coolers built for the life of the power plant

Young *products on duty* provide dependable cooling for these two 330 horsepower Packaged Compressors. These compressors, plus one 300 horsepower unit, will handle 24 mmcfd. Residue gas from the main plant will be picked up at 2000 psig and boosted to 4000 psig for injection into the reservoirs. Young's dependability of performance is *built-in!* Quality features include: Improved Mono-Weld design for greater strength to withstand the toughest use; new developments of core structures and arrangements of components provide greater cooling capacity. Young jacket water coolers furnish trouble-free, economical cooling for gas, gasoline, Diesel engines and fluid.

Write Dept. L-216 for FREE catalog No. 1351



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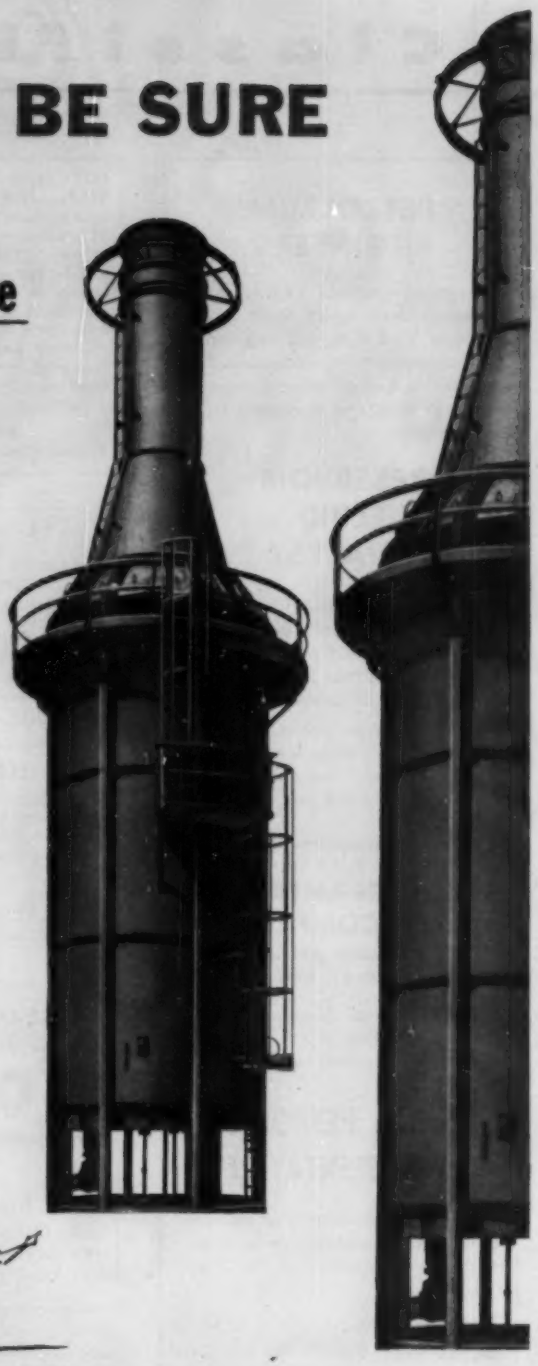

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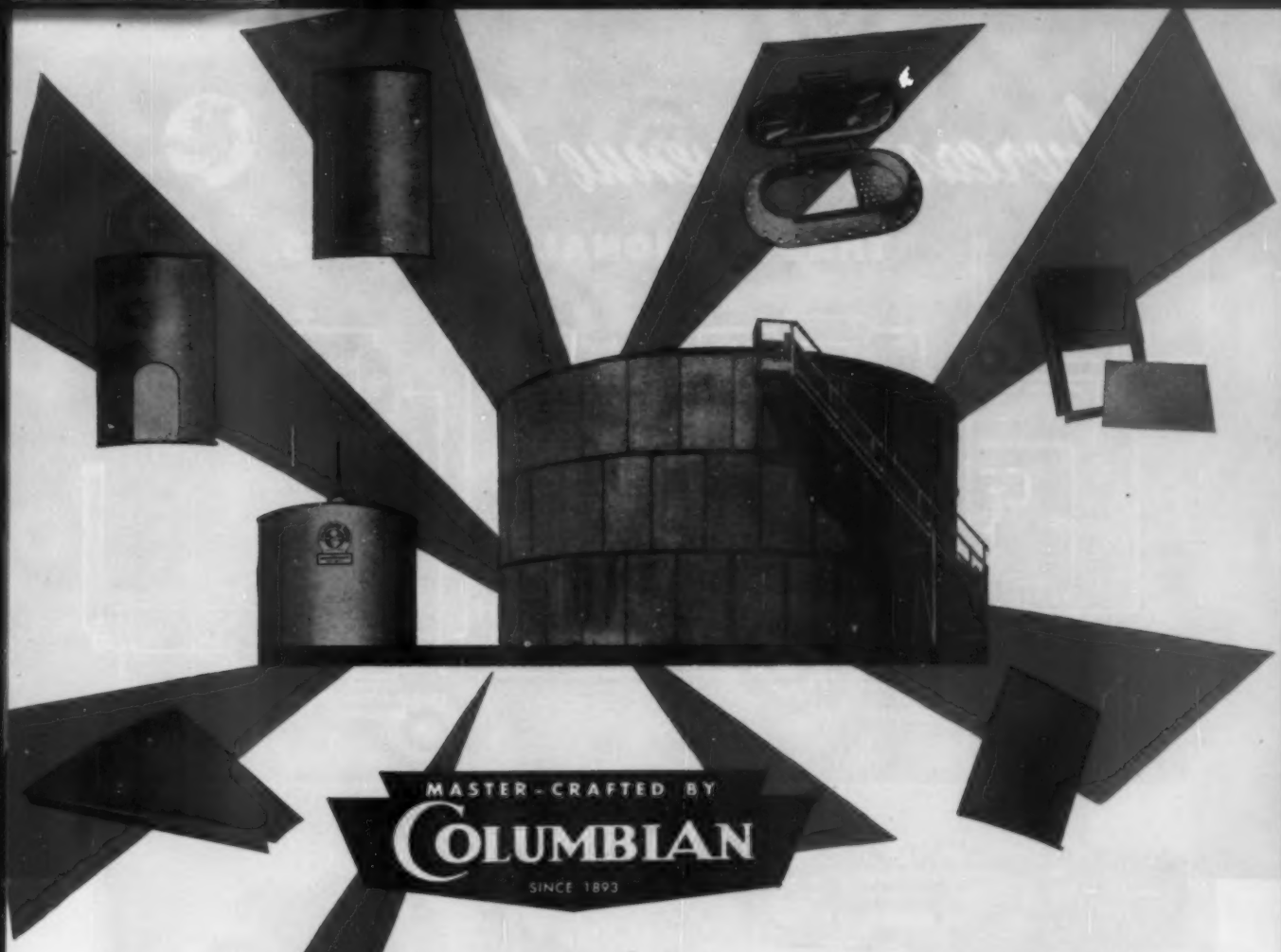

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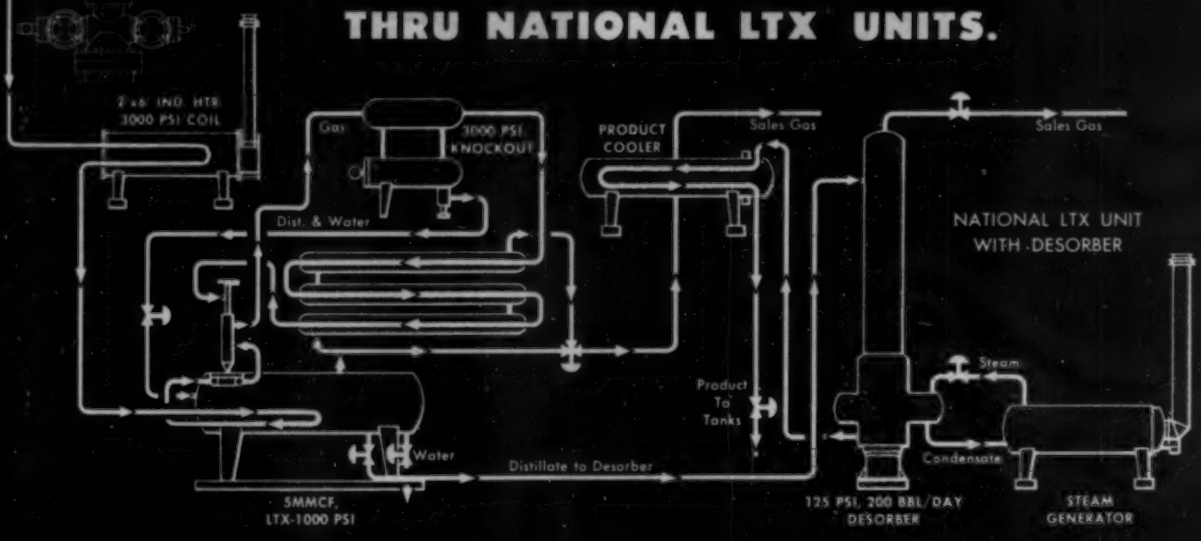
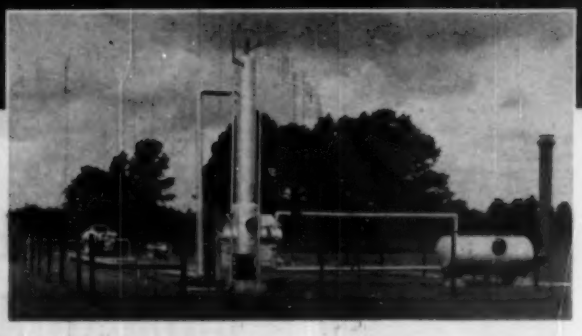
THRU NATIONAL LTX UNITS.





Installation of a National LTX Unit with desorber on this gas distillate well near Shreveport, Louisiana, INCREASED the recovery 14 barrels of stock tank liquid per MMCF of sales gas produced.* The well originally tested 70 barrels per MMCF with conventional separation equipment and increased to 84 barrels per MMCF of sales gas produced after the installation of LTX equipment. The LTX unit operates at approximately 300 psi and 5°F. Flowing pressure is approximately 2500 psi.

To receive maximum recovery from your lease, contact a National Tank Company representative in your area. You will find him nearby with "know how" and production equipment ready to serve your producing needs.

**For a more finite economic evaluation, the differences in recovery should be based on the unit of well effluent. This is not data that can easily be observed in the field for it requires calculations based on the wellstream hydrocarbon composition. Such determinations are often valuable.*

It's a National®

NATIONAL TANK COMPANY

TULSA, OKLAHOMA

FASTER MOVES
FASTER PULLING

. . . WITH 'ROUND THE CLOCK RUGGED DEPENDABILITY

FRANKS *Cruiser*

Franks Cruiser, the most widely accepted pole mast well servicing unit, has set the standard of performance and economy for rod and tubing jobs.

Franks Cruiser is especially economical in areas where there is considerable waiting time on such operations as swabbing.

Franks Cruiser is legal in weight; affords faster moving; faster rig-up and down; and is known for its ruggedness and dependability.

Contractors like Franks Cruisers because superintendents prefer them on their servicing jobs.

Only Franks offers "On the Spot" field service with stock of parts and factory trained personnel available at Alice, Compton, Casper, Farmington, Great Bend, Houston, Kilgore, Odessa, Seminole, Edmonton and Tulsa.

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DIVISION CABOT SHOPS INC
WELL SERVICING AND DRILLING UNITS
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"ON THE SPOT" FIELD SERVICE

CABOT
SHOPS, INC.

These are the 4 big reasons why operators get better service from LANE-WELLS PACKERS

1 LONGER LIFE

2 EASY PULLING

3 LEAK-PROOF PACKOFF

4 POSITIVE SETTING

And here are a few of the design and construction features which give these 4 big values:

SLYDEZE dovetailed slips which can't catch or hang up the packer, and don't "freeze" to the cone.

CROSS-CUT wickers which hold firm on hardest casing, without harming the casing.

CONTROLLED-EXPANSION sealing element which springs back to shape upon release, and doesn't "vulcanize" to the casing.

LIFTING LUGS which insure release of the sealing element.

LARGE BY-PASS (in valve-type packers) which gives fast running in fluid.

FULL-DIAMETER mandrel which allows free passage of tools.

Tomorrow's Tools Today!

There's a LANE-WELLS PACKER "tailor-made" to fit *your job—write for complete information.*

LANE WELLS COMPANY

GENERAL OFFICES, EXPORT OFFICE, PLANT • 5610 SO. SOTO ST., LOS ANGELES 58

Los Angeles • Houston • Oklahoma City • Lane-Wells Canadian Co. in Canada • Petro-Tech Service Co. in Venezuela

Of Things To Come . . . In Oil

NATURAL GAS BILL SUPPORT IN CONGRESS will be cut considerably as a result of primary elections and retirement from office. Loss of votes for and against the Harris Bill, sent through the House of Representatives last year, shows a present head-count of 188 favoring and 191 against. Rep. Walter Rogers of Texas warned the industry to be wary of reports that President Eisenhower would sign a new gas bill, and indicated that "tricky language" is being used to enlist his support against such a measure.

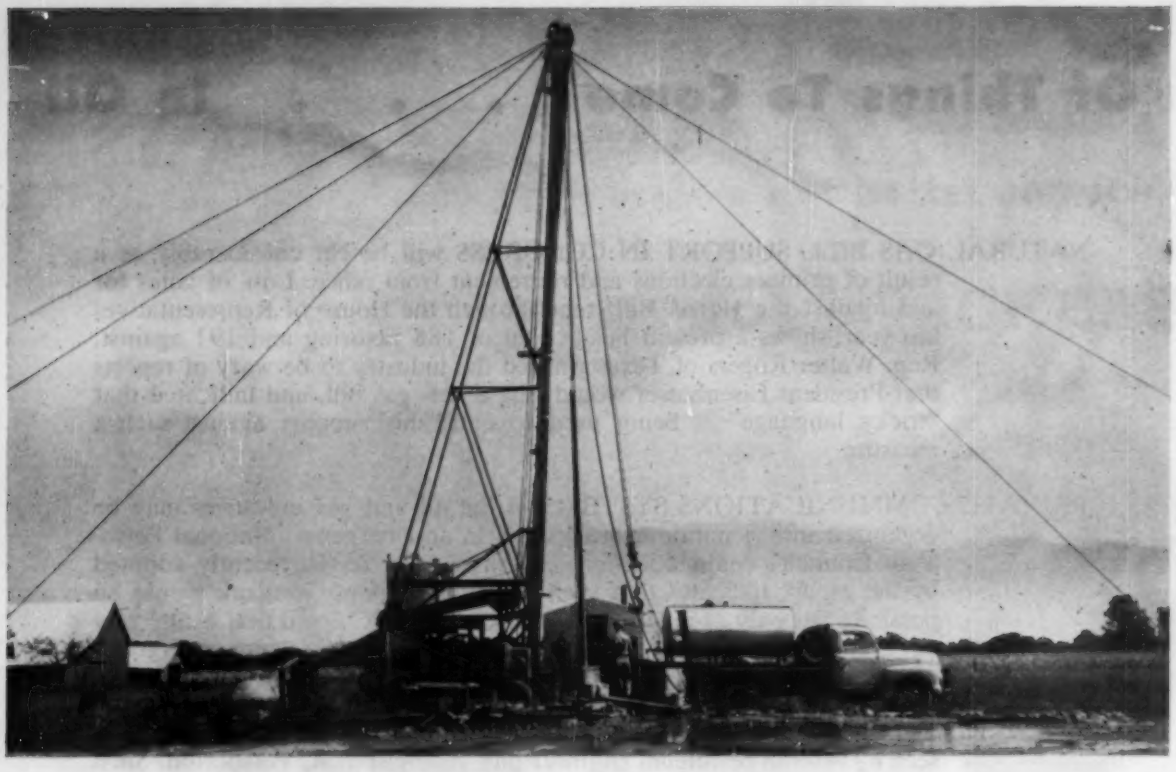
PRIVATE COMMUNICATIONS SYSTEMS of the oil and gas industries may be organized into a nationwide network in an emergency. National Petroleum Council's communication committee, in a report recently adopted by the group, indicates that such a national defense network would be possible, but only at much time and expense. NPC urged that if any new oil agency is set up by government, a national petroleum emergency communications director should be created.

SUBMARINE TUNNELS FOR CALIFORNIA OFFSHORE DRILLING are foreseen by veteran petroleum engineer and geologist J. R. Pemberton. Such underwater chambers, similar to those now being used by Welch coal miners, would cut drilling and well maintenance problems expected in oil exploitation forthcoming along the Pacific coastline. Pemberton said that such a project would probably be applicable in the offshore extension of the Wilmington field in Southern California, and states that he knows of "two nationally noted contractors willing to take any part" of such a deal.

QUADRUPLE WELL COMPLETION may be being made as this magazine goes to press. Officials of two manufacturing concerns have confirmed orders calling for a quadruple Christmas tree with four bores and valves in a single body, and packers are being designed for a quadruple job. Plans are to make it through four independently run and suspended strings of full-size tubing. Well location and its operator are not yet known. Mining division of Aluminum Company of America is credited with making the industry's first triple completion in a South Louisiana well this spring.

GULF OF MEXICO TIDELANDS OPERATORS can and will survive the toughest of storms expected in the oncoming hurricane season. Well-laid plans of most offshore companies successfully averted the force of Hurricane Flossy, first major 1956 Gulf storm. Experience in weathering Flossy gave operators additional information necessary to successfully fight future gales. Gulf Oil suffered "minor losses" from Flossy, estimated at $137,000; Humble indicated that shutdown time was its greatest loss.

What's in it for YOU?



Steady, dependable performance . . . that's what you expect and get with a versatile Bucyrus-Erie spudder on your drilling and servicing operations. These modern mobile rigs speed top-to-bottom drilling, drilling-in, or the multiple jobs included under servicing and well completion. They are designed to assure pace-setting performance hole after hole with quick easy moves, and reduced costs all down the line. They are built to stand up to full-time diet of rugged duty.

Such outstanding dependability — the backbone of true satisfaction — is the result of Bucyrus-Erie's close attention to the little things through a skill born of pride and craftsmanship. At Bucyrus-Erie, *quality* comes FiRST — quality in design, in materials, in manufacture, in service.

Join the thousands of satisfied owners who know you can count on Bucyrus-Erie spudders to deliver top performance year after year. See your nearby Bucyrus-Erie distributor or write for complete information on any of these spudders. Do it soon. 32556

Quality in the making: Ruggedness and durability are built into the frames and derricks of Bucyrus-Erie spudders through use of most modern electric welding techniques.

60-L Top-to-bottom drilling to 1,500 ft.; Servicing to 2,000 ft.; Swings up to 2,750 lbs. of tools.

28-L Top-to-bottom drilling to 2,500 ft.; Servicing to 3,000 ft.; Swings up to 3,700 lbs. of tools.

36-L Top-to-bottom drilling to 3,500 ft.; Servicing to 4,000 ft.; Swings up to 5,000 lbs. of tools.

48-L Top-to-bottom drilling to 6,000 ft.; Servicing to 7,000 ft.; Swings up to 6,700 lbs. of tools.

BUCYRUS ERIE

SOUTH MILWAUKEE
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Your Wickwire Rope Distributor and our metallurgist . . . work together for you

This metallurgist—who is responsible for the quality of our rope wire—is with your Wickwire Distributor every time he makes a call.

True, he's physically in his laboratory, supervising the thorough testing *of both ends of every coil* of wire to assure uniformity throughout the coil. But, whenever your Wickwire Distributor calls, he has the full assurance that metallurgists like this are constantly making sure that the product has the right chemical and physical properties to give long, dependable service.

It's just one more reason why your Wickwire Distributor knows he's got top-quality wire rope, slings and strand to sell . . . and that these products will serve you well.

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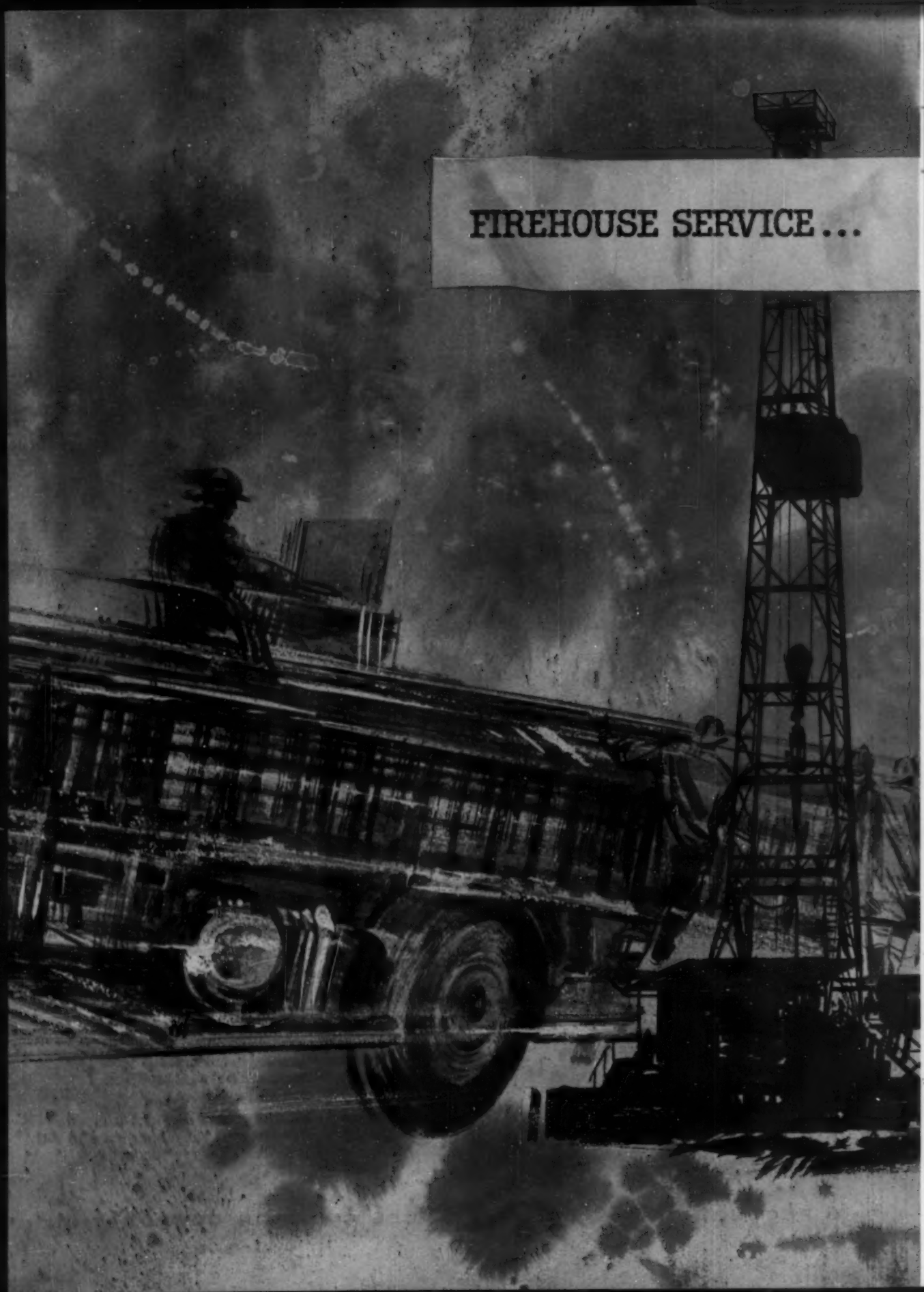
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Johnston is tops in testing

and here's why

Johnston realized long ago that just to develop the world's best drill stem tester wasn't enough. Sure, the Johnston Tester is the most dependable way to evaluate a formation, short of a permanent completion. Granted, that the Tension Type Pressure Recorder perfected by Johnston is the most sensitive, the most accurate by far (5/100 of 1%). What if Johnston's development program *is* backed by one of the largest, most respected, independent research groups in the business!

To make Johnston "tops in testing" we also attached great importance to (1) putting our tools only in the hands of carefully trained testers, and (2) getting the tools and the tester to the well location as quickly as possible to prevent the waste of your rig time.

There is a difference in drill stem testing . . . and Johnston makes the difference. Let us show you.

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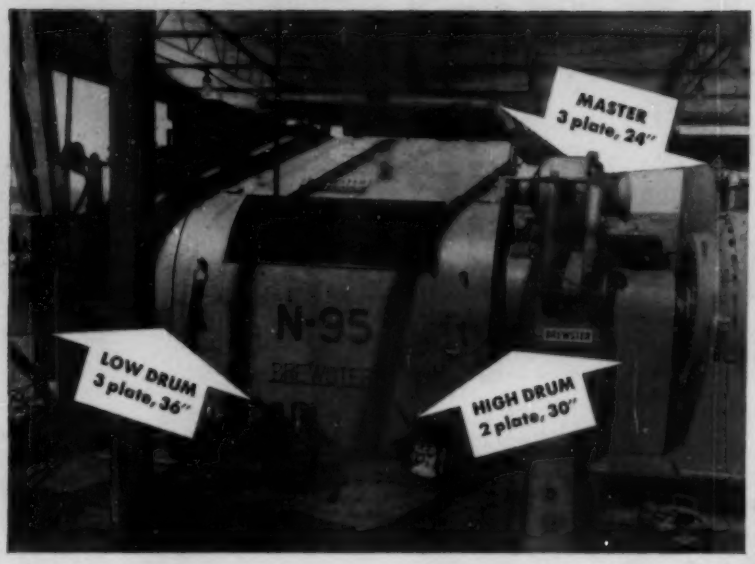

Here's an over-all view of Marcum Drilling Company's rig working near Andrews, Tex., and a close-up of the Brewster N-95 Drawworks. The N-95 Drawworks uses Twin Disc PO Air Clutches as standard equipment for the master and rotary clutches as well as on the high and low-speed drums. Below: Twin Disc Model PO Air Clutch.

Off the bottom with 10,000′ of pipe on the high-drum clutch!

Working near Andrews, Tex., Marcum Drilling Company has a rig using a Brewster N-95 Drawworks *equipped throughout* with Twin Disc Model PO Air Clutches. "In one 28-day period alone," says Marcum's tool pusher, C. R. Rucker, "we made from 9 to 11 round trips daily fishing for 16 lost drill collars. The job was so tough we broke a 300-ton hook. Any clutch that can stand up to the punishment the rig took on that job just has to be good!"

Since this rig went into operation in mid-1955, it has drilled some 48,000 feet of hole. Mr. Rucker summed up the ruggedness of the Twin Disc PO Air Clutches in this way: "I doubt if we've ever pulled more than 100 stands of pipe with the low-speed clutch. All the work has been done with the high-speed drum and we've come off the bottom with 10,000 feet of 4½" pipe with that clutch!"

No, you don't baby the drawworks on a drill rig—not if you're after production. That's why so many manufacturers use Twin Disc Clutches as *standard equipment*. They know from experience — from operations like Marcum Drilling Company's — that Twin Disc Air Clutches are designed and built to take the most severe service the oil fields can give.

For complete details on Twin Disc Model PO Air Clutches and other power transmission products, write to your nearest Twin Disc District Office. Dallas: 1511 Turtle Creek Boulevard; RIverside 3014. Tulsa: Enterprise Building, Sixth and Boston; GIbson 7-1578. Los Angeles: 2950 Leonis Boulevard; LOgan 8-3309.

TWIN DISC
TWIN DISC
Clutches

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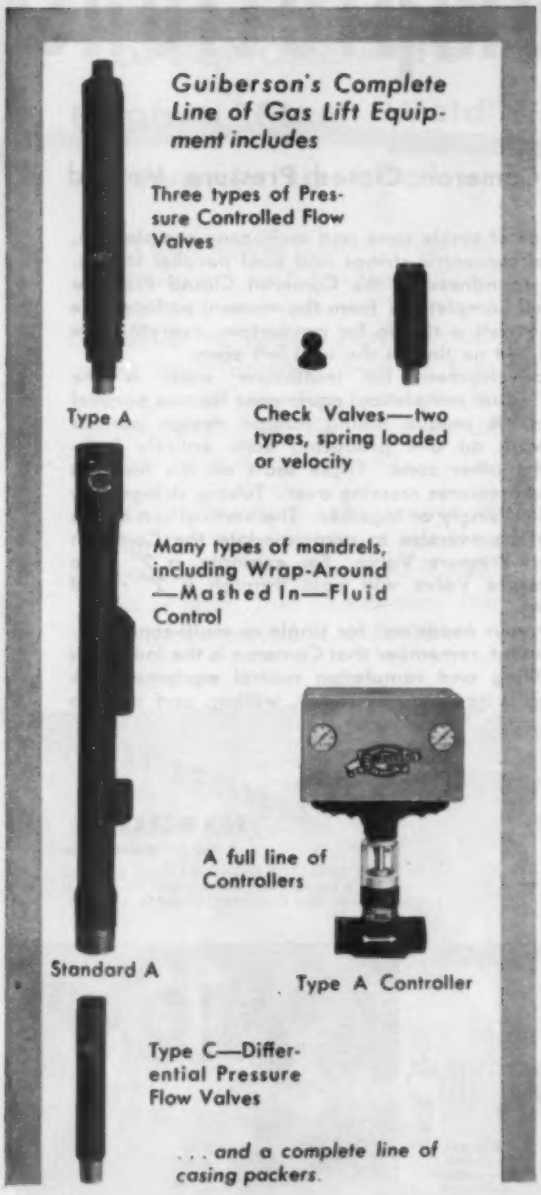
BRANCHES OR SALES ENGINEERING OFFICES: CLEVELAND • DALLAS • DETROIT • LOS ANGELES • NEWARK • NEW ORLEANS • TULSA

watch lift COSTS GO DOWN

with GUIBERSON GAS LIFT EQUIPMENT


Guiberson's Complete Line of Gas Lift Equipment includes
Three types of Pressure Controlled Flow Valves
Type A
Check Valves—two types, spring loaded or velocity
Many types of mandrels, including Wrap-Around —Mashed In—Fluid Control
A full line of Controllers
Standard A
Type A Controller
Type C—Differential Pressure Flow Valves
. . . and a complete line of casing packers.

When wells won't flow, operators in many fields are meeting rising oil production costs with gas lift. And more and more engineers and field men are finding that Guiberson equipment plus Guiberson experience is the way to the lowest gas lift cost with the greatest economy in initial installation.

Guiberson's line of equipment is complete, designed to solve almost every type of gas lift problem. Guiberson experience, derived from thousands of satisfactory installations, is your assurance that your well will give maximum production for a maximum length of time. No matter what your gas lift problem—intermitting or continuous flow; using lease gas or recycled gas, from single or dual producing zones—look to Guiberson for the equipment and experience that will cut your gas lift costs.

Write us for a recommended gas lift installation for your well.

Guiberson Gas Lift Equipment is protected by the following patents:
2,156,429 2,227,132 2,292,768 2,347,600 2,377,981
2,186,454 2,230,167 2,305,256 2,358,544 2,411,315
2,188,006 2,271,620 2,340,088 2,361,718 2,510,342
Other patents pending.

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ESTABLISHED 1919
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Everywhere

SAFE, FLEXIBLE, TWO-STRING

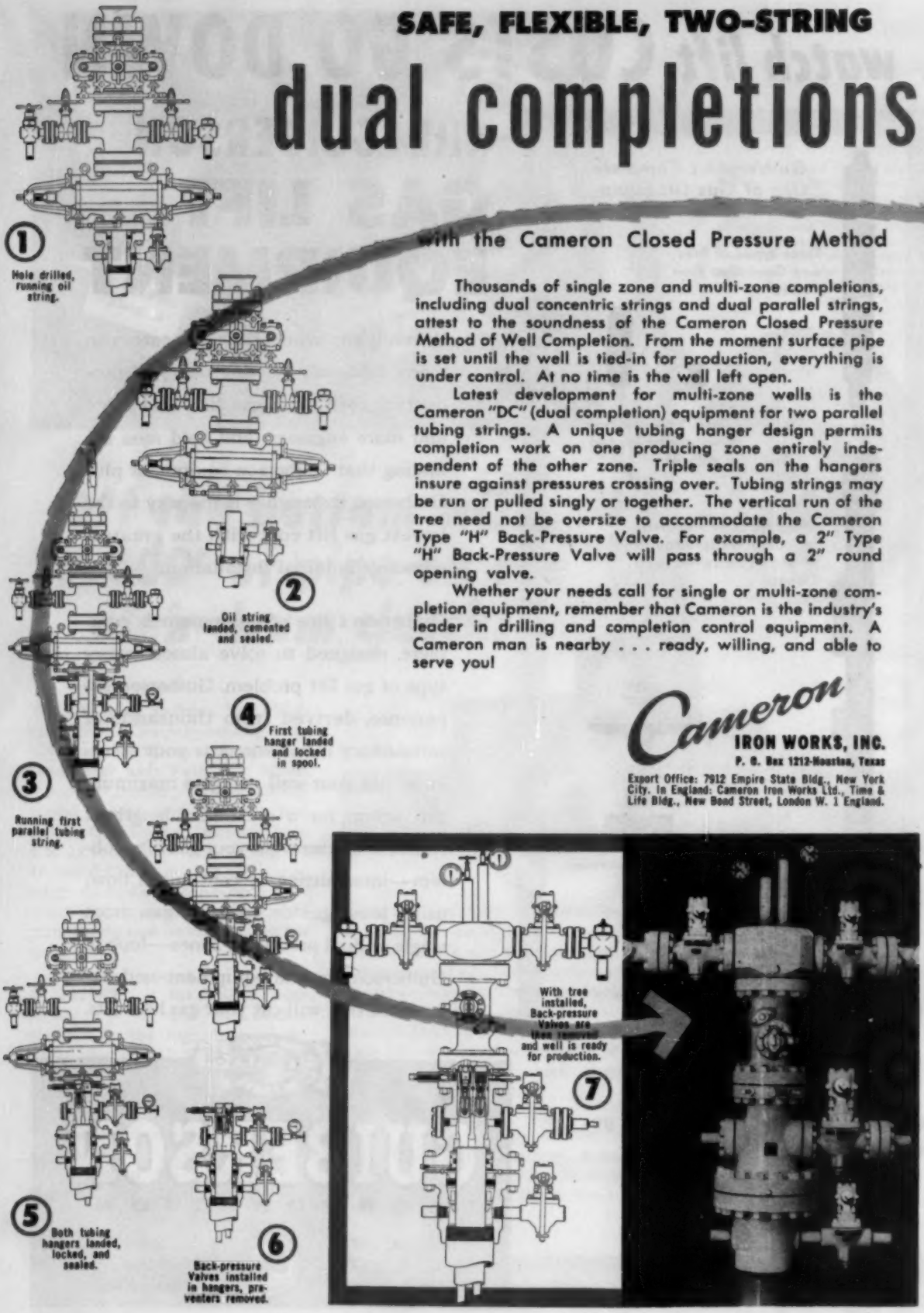
dual completions

with the Cameron Closed Pressure Method

Thousands of single zone and multi-zone completions, including dual concentric strings and dual parallel strings, attest to the soundness of the Cameron Closed Pressure Method of Well Completion. From the moment surface pipe is set until the well is tied-in for production, everything is under control. At no time is the well left open.

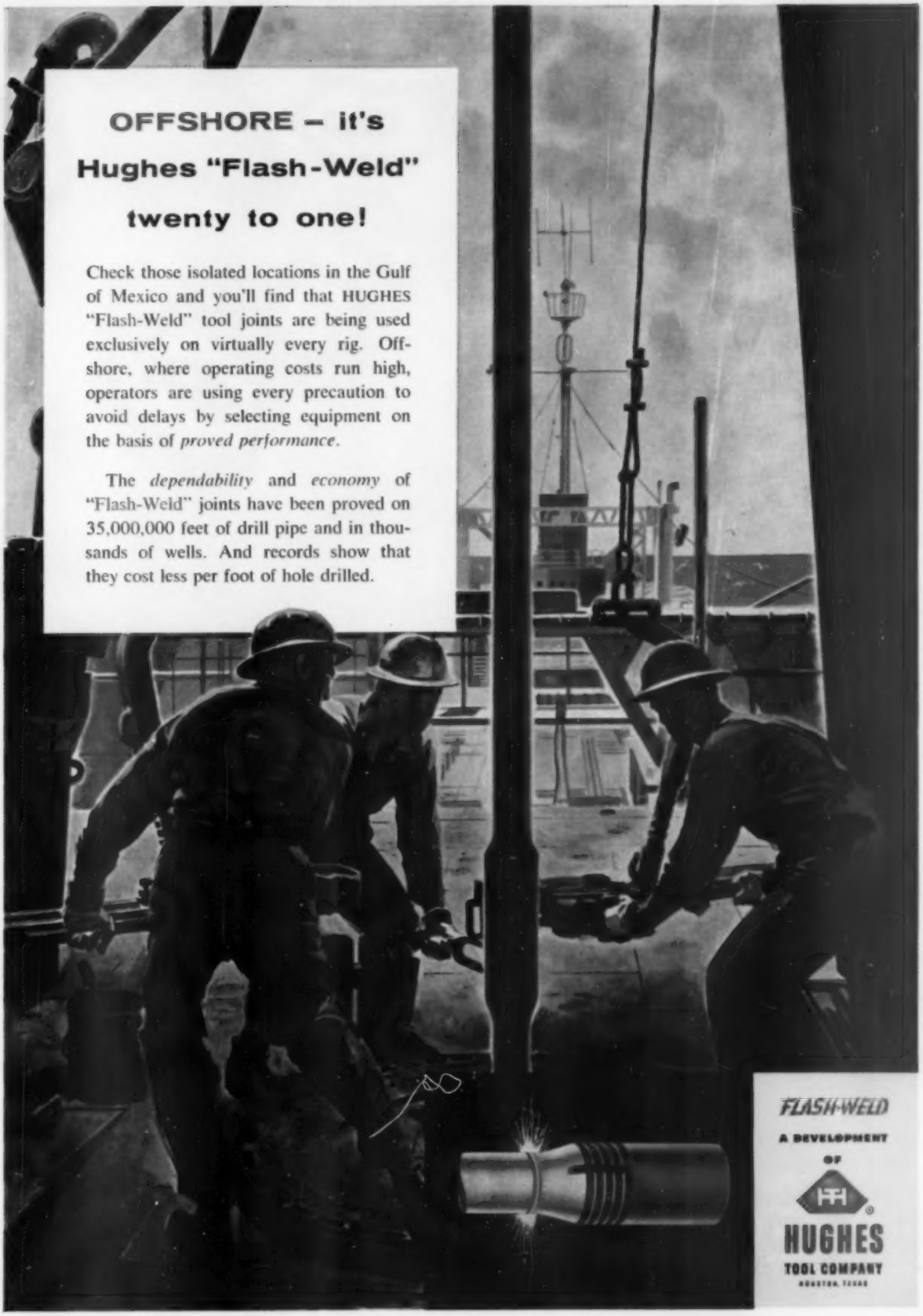
Latest development for multi-zone wells is the Cameron "DC" (dual completion) equipment for two parallel tubing strings. A unique tubing hanger design permits completion work on one producing zone entirely independent of the other zone. Triple seals on the hangers insure against pressures crossing over. Tubing strings may be run or pulled singly or together. The vertical run of the tree need not be oversize to accommodate the Cameron Type "H" Back-Pressure Valve. For example, a 2" Type "H" Back-Pressure Valve will pass through a 2" round opening valve.

Whether your needs call for single or multi-zone completion equipment, remember that Cameron is the industry's leader in drilling and completion control equipment. A Cameron man is nearby . . . ready, willing, and able to serve you!


1
Hole drilled, running oil string.
2
Oil string landed, cemented and sealed.
3
Running first parallel tubing string.
4
First tubing hanger landed and locked in spool.
5
Both tubing hangers landed, locked, and sealed.
6
Back-pressure Valves installed in hangers, preventers removed.
7
With tree installed, Back-pressure Valves are then removed and well is ready for production.

Cameron
IRON WORKS, INC.
P. O. Box 1212-Houston, Texas

Export Office: 7912 Empire State Bldg., New York City. In England: Cameron Iron Works Ltd., Time & Life Bldg., New Bond Street, London W. 1 England.



OFFSHORE – it's Hughes "Flash-Weld" twenty to one!

Check those isolated locations in the Gulf of Mexico and you'll find that HUGHES "Flash-Weld" tool joints are being used exclusively on virtually every rig. Offshore, where operating costs run high, operators are using every precaution to avoid delays by selecting equipment on the basis of *proved performance*.

The *dependability* and *economy* of "Flash-Weld" joints have been proved on 35,000,000 feet of drill pipe and in thousands of wells. And records show that they cost less per foot of hole drilled.

FLASH-WELD

A DEVELOPMENT

OF

HUGHES

TOOL COMPANY

HOUSTON, TEXAS

● world's most widely used rock bit

Hughes bits have left their mark in virtually every oil and gas field of the world. Their performance is the standard by which the performance of all rock bits is measured.

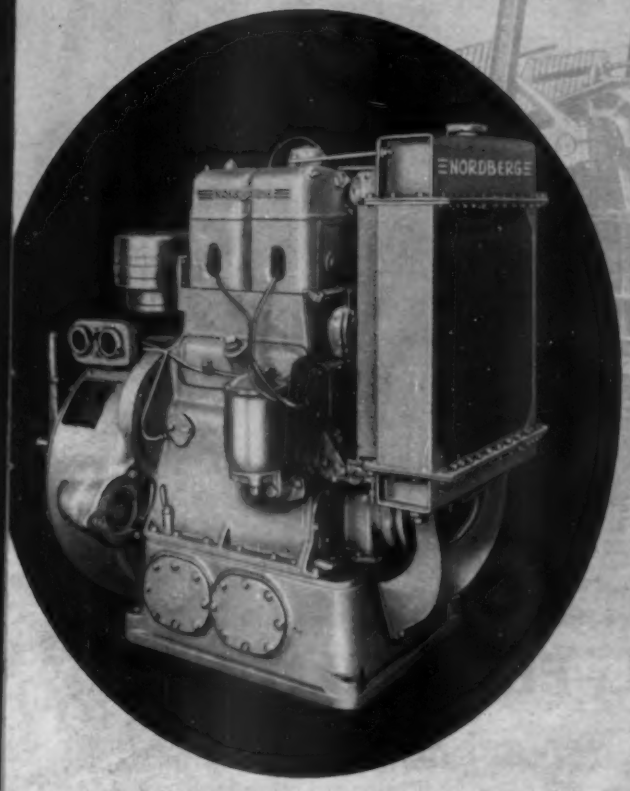
Since 1909, more than a *billion feet of hole* has been drilled with HUGHES bits. This is the world's greatest accumulated rock bit experience! And it goes to work for you with every Hughes bit you run.

HUGHES TOOL COMPANY · Houston, Texas

NORDBERG

POWER CHIEF®

OIL FIELD ENGINES



• Nordberg Power Chief Gas Engines are now built in compact single-cylinder and two-cylinder sizes, rated from 18 to 36 horsepower at medium speed to handle a wide range of pumping requirements.

. . . setting new records for 'round-the-clock PRODUCTION PUMPING

• Before you consider *any* production pumping engine, it will pay you to consider that Nordberg *Power Chief* Gas Engines are setting new records for 'round-the-clock service. Many actual *Power Chief* case histories show over 30,000 hours of continuous pumping operation—*with original rings, pistons, liners, bearings and crankshaft still in place!*

Here, then, is positive proof that Nordberg *Power Chief* engines really deliver the kind of rugged, day-in, day-out power you need for dependable production pumping service at the very lowest maintenance cost.

For further details, mail the coupon today.

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DIESEL • DUAFUEL® AND SPARK-IGNITION GAS ENGINES

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LOUISIANA & MISSISSIPPI—Rogers Diesel Engineering Co., New Orleans, La.
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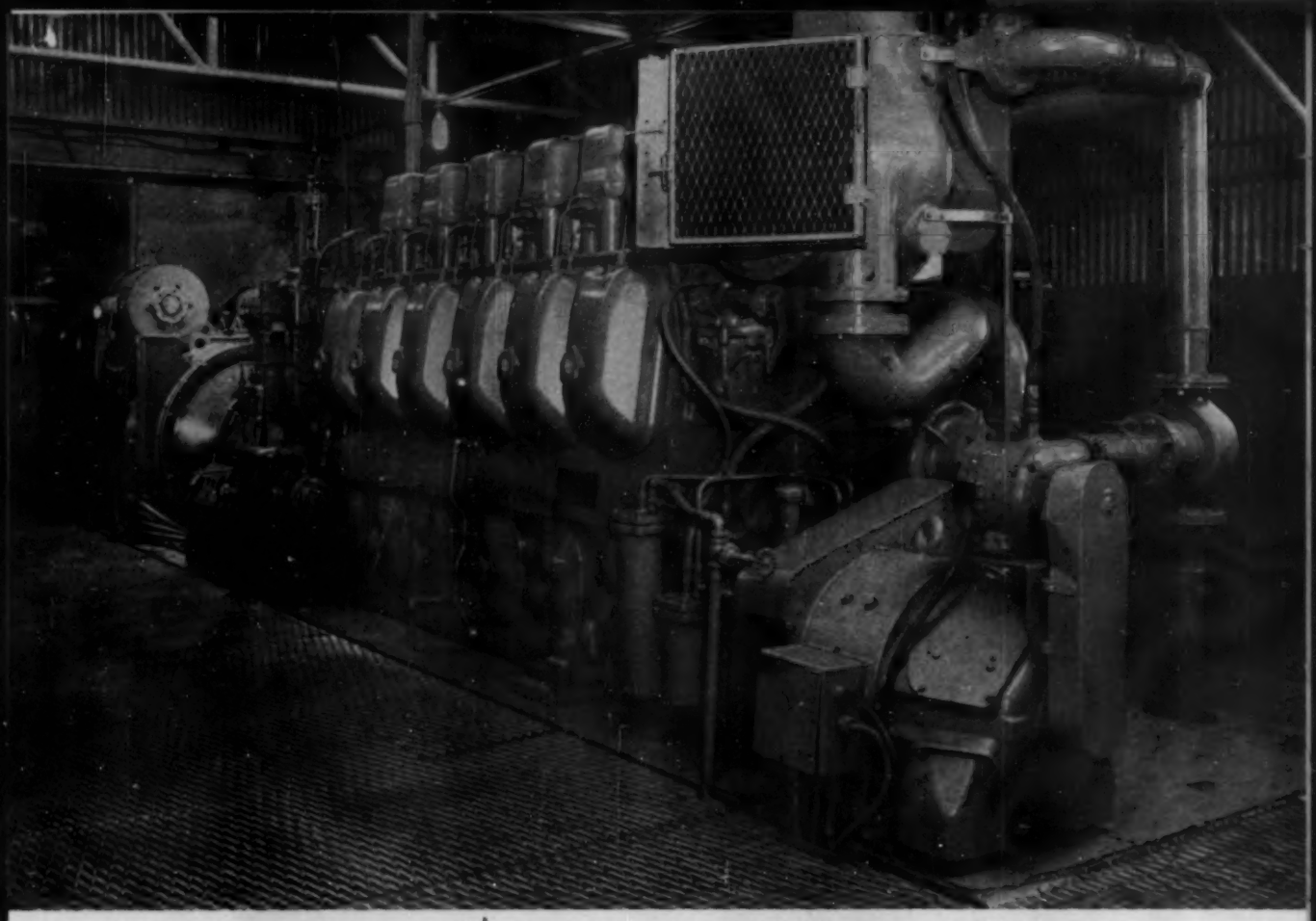

ALCO 251-B DIESEL ENGINE *in service on Shoreline Drilling Company oil-well drilling barge. Barge recently completed its second hole, which went 15,000 ft deep. First* ALCO *plant, owned by Bateman Drilling Co., has drilled over 80,000 ft. Offshore Company's first* ALCO*-powered rig has completed two holes. Drillers report excellent performance of* ALCO *equipment.*

NEW ALCO DRILLING PLANT GIVES COMPLETE POWER, SMOOTH CONTROL, FLEXIBILITY

Plant Provides All Power For Drilling; Includes Split-Second, Reliable Control; Skid-Mounted Units Solve Weight Distribution and Add Flexibility.

The ALCO drilling plant provides all the advantages of diesel-electric power: smooth, pin-point control, steady acceleration without load shock to engines and other equipment, power that's instantly available. It means that you can spend more time drilling, less time in mechanical control changes and equipment maintenance. It even means that you spend less time changing bits, or pulling your string out of the hole for any reason. In addition, the ALCO plant can drill as long as one engine is running—it does not depend on auxiliary generators or engines.

All components are skid-mounted. You distribute weight on a barge as required, save setup time on land installations. Components can be trucked from location to location.

Two engines in the ALCO plant provide 1370 hp for draw-works drive and 600 hp for each of two mud-pump drives, plus power for lighting and other auxiliaries. A wide variety of modifications is available, such as larger mud-pump, rotary and coring reel drives.

The ALCO plant's cost is comparable to that of an ordinary plant. It is built and backed by the pioneer of locomotives and diesel-electric power. Contact your nearest ALCO representative or write P. O. Box 1065, Schenectady 1, N. Y. for details.

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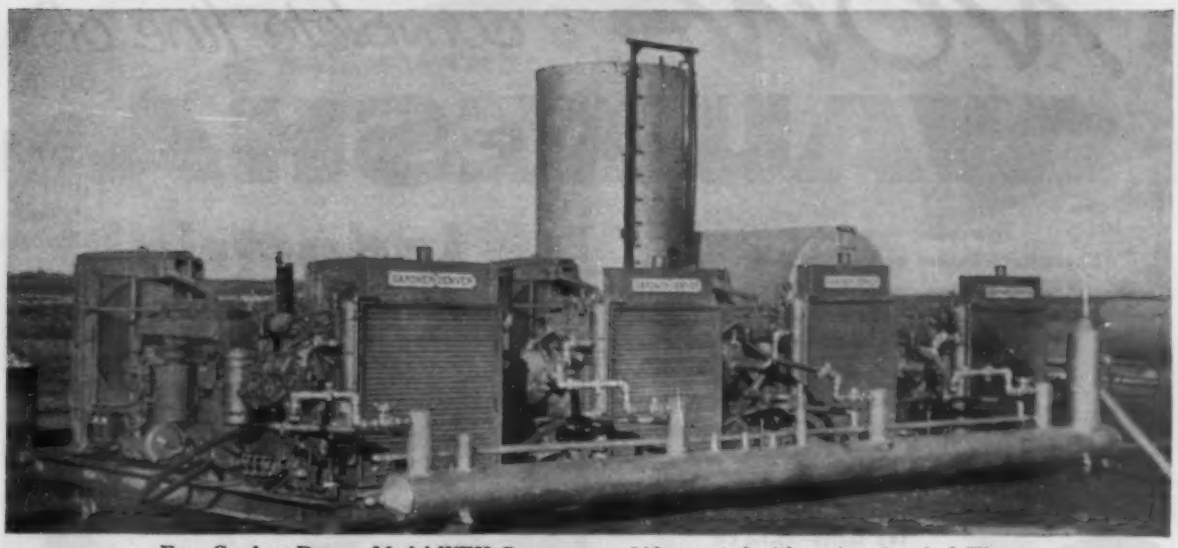
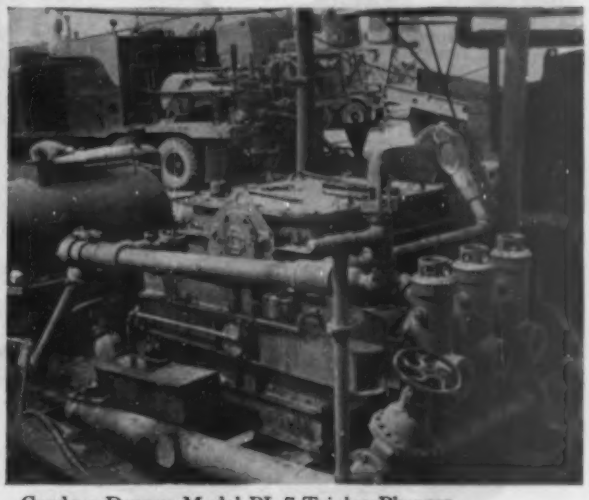


Four Gardner-Denver Model WEK Compressors skid-mounted with engines for air drilling.

4¾" x 11" Model RX Compressors boosting air pressure for mud aeration.



Gardner-Denver Model PL-7 Triplex Plunger Pump works on mud aeration job.

In air drilling and mud aeration

GARDNER-DENVER FITS ALL JOBS

There are Gardner-Denver quality pumps and compressors designed to handle any air drilling or mud aeration job. Call your nearest Gardner-Denver representative for details. Gardner-Denver service specialists are on call in: Houston, Corpus Christi, Odessa, Wichita Falls, New Orleans, Shreveport, Oklahoma City, Ellinwood, Casper, Edmonton, Tulsa, Pittsburgh and Los Angeles.

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Waukesha now offers you a superb line of Enginators—backed by half a century of experience in building heavy-duty internal combustion engines and electrical equipment. Designed for reliable performance on all types of fuel, these Waukesha power units supply accurately balanced engine and generator combinations in applications requiring a smooth, steady flow of power for continuous, intermittent and stand-by duty.

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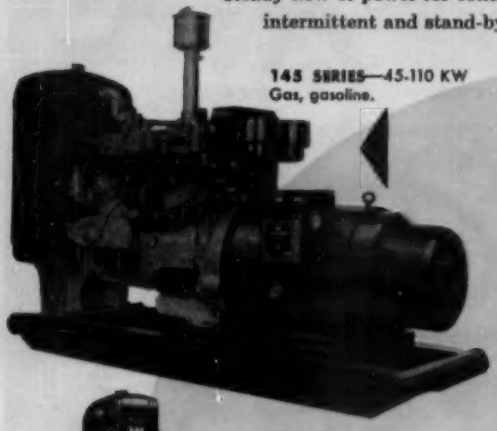
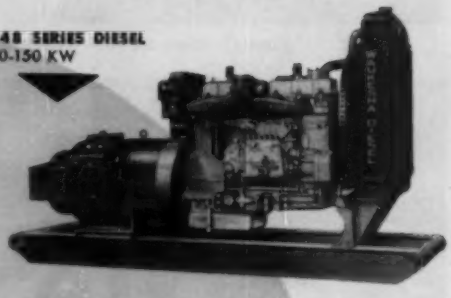
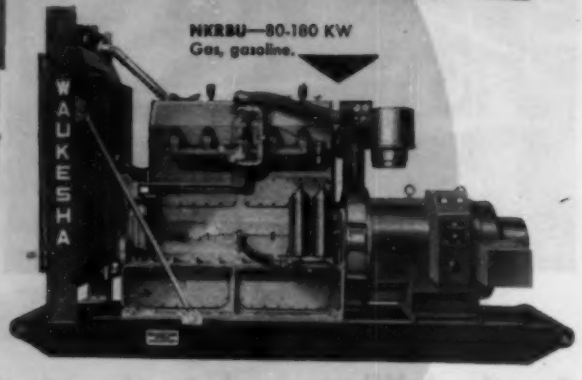
Gas, gasoline.



148 SERIES DIESEL
50-150 KW

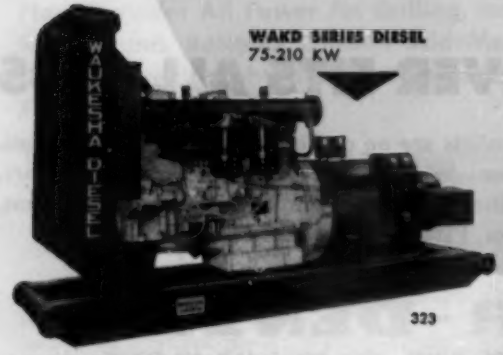


NKRBU—80-180 KW
Gas, gasoline.



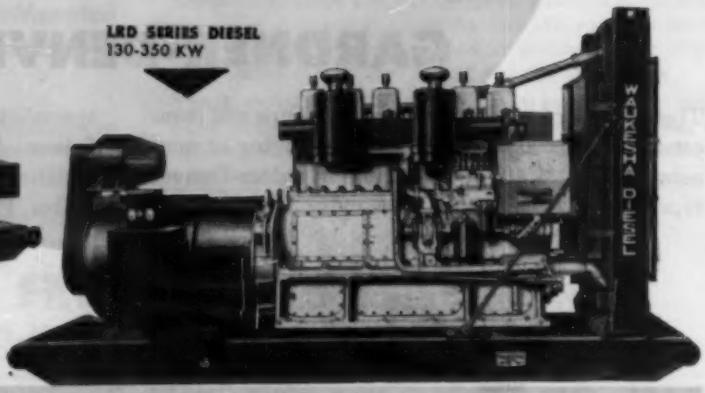
WAK SERIES—75-170 KW
Gas, gasoline.

WAKD SERIES DIESEL
75-210 KW



323

LRD SERIES DIESEL
130-350 KW



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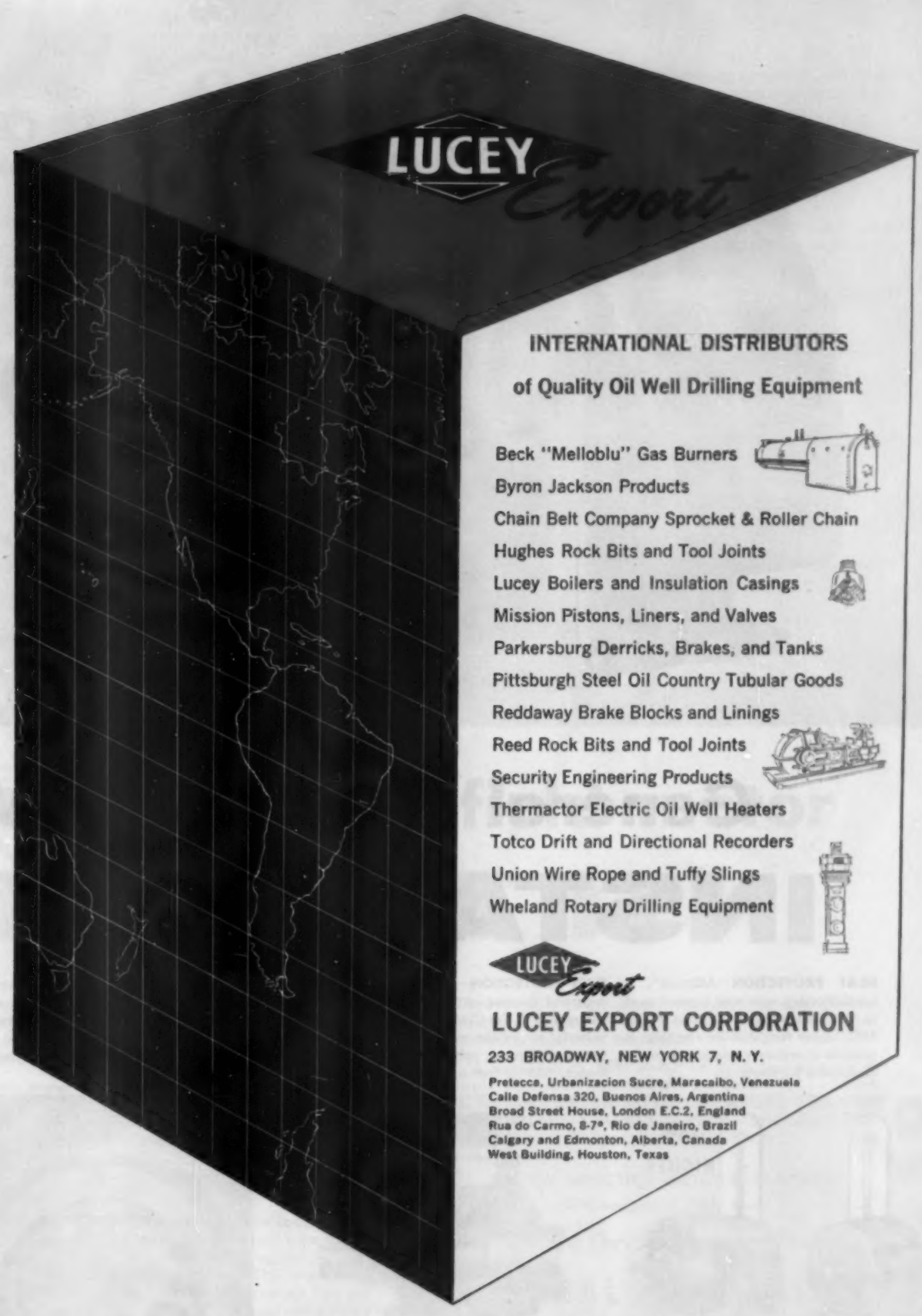

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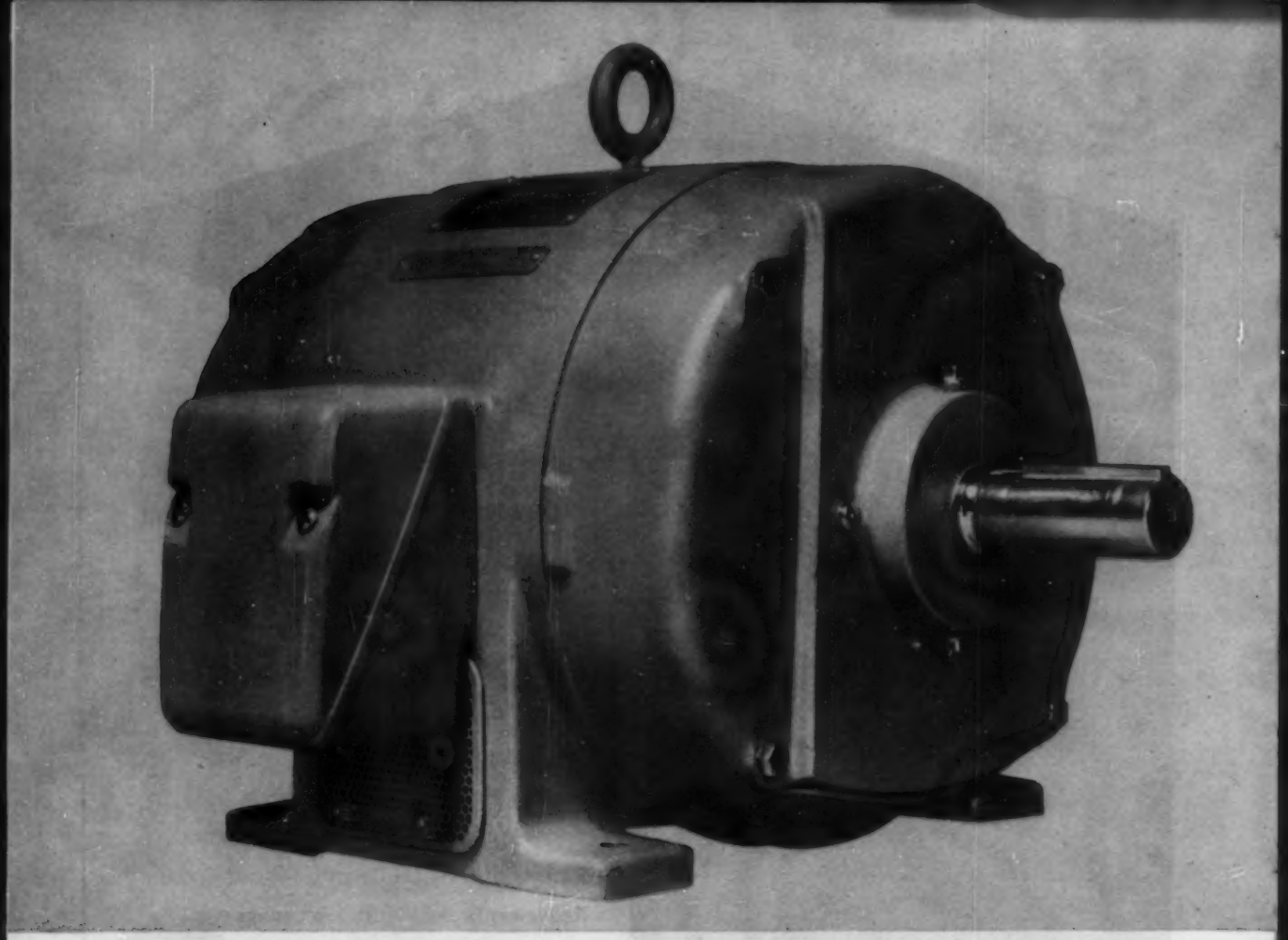


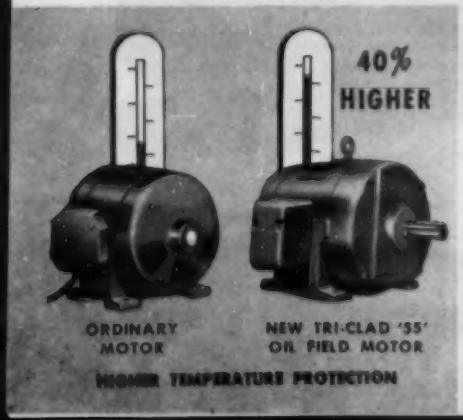
General Electric's NEW

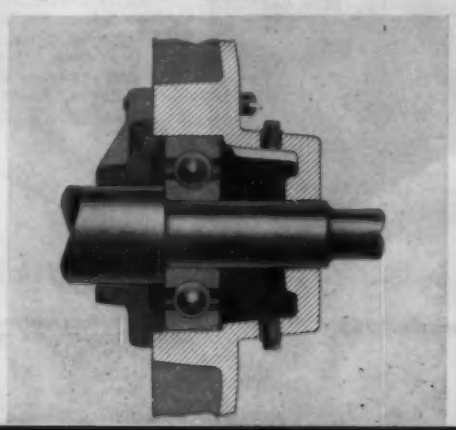
INSTALL IT...

HEAT PROTECTION—Alkanex*, a revolutionary new wire enamel used in the field windings, allows up to 40% higher temperature rise than is possible in ordinary motors, virtually eliminates burnouts.

DUST PROTECTION—Closely machined bearing caps and housing on each side of bearings, plus the new G-E Tri-Clad "55" oil field motor's low velocity air intake system, keep dirt and dust out of vital parts, help give added protection for longer, trouble-free operation.

MOISTURE PROTECTION—Field windings, coated with water-shedding silicone Dri-Film*, plus cast-iron frame construction and close fits between all joining surfaces, help prevent motor failure due to moisture.





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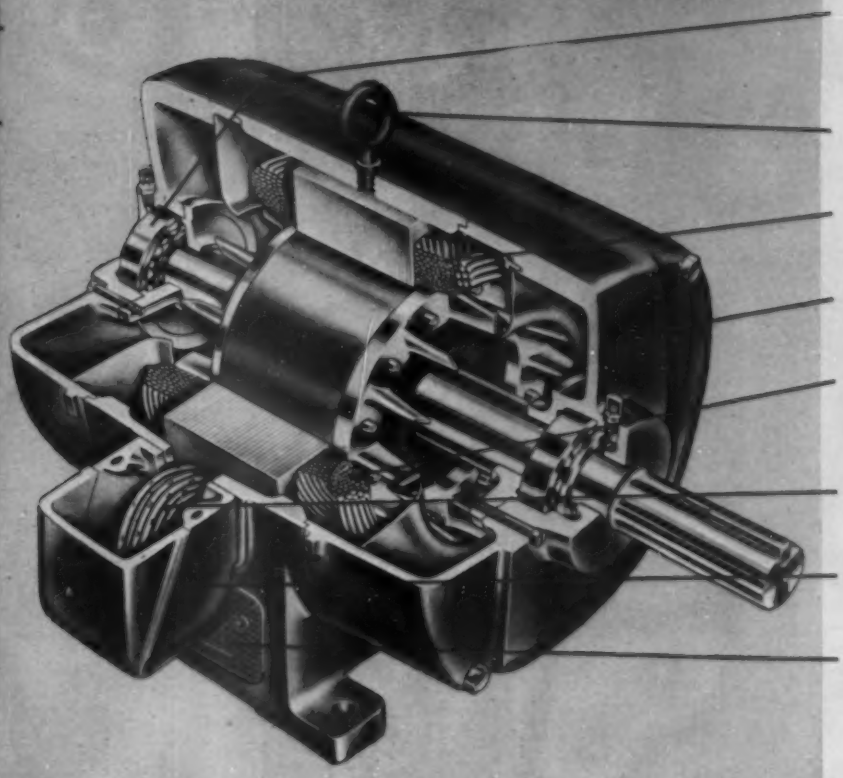

1. Advanced bearing system will last longer without regreasing than any other motor bearing system.

2. Convenient eyebolt cuts installation time, —permits easier handling.

3. Water-shedding stator windings virtually eliminate breakdown due to moisture.

4. Rugged cast-iron frame helps prevent corrosion and accidental damage.

5. Class 'B' insulation system with revolutionary Alkanex* wire enamel allows up to 40% higher temperature rise.

6. Perma-numbered leads are easy to read even when taped or clipped.

7. Easy-access conduit box is large and roomy for fast wiring.

8. Removable screens protect motor against damage from rodents and rocks.

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General Electric's all-new Tri-Clad "55" oil field motor is specially designed and engineered for long, trouble-free operation on rugged, outdoor pumping applications.

This motor will run far longer without attention than ordinary motors because it is protected against heat, dust and moisture. Burnouts have been virtually eliminated by the use of Class 'B' insulation made from new "miracle" materials Alkanex, heat-resistant enamel wire, and Mylar† mica-glass laminate slot and phase insulation.

The high heat resistance of this new insulation means you get more horsepower per pound in a more compact, cast-iron frame, because of higher temperature protection possible with Alkanex. The large grease reservoir and revolutionary bearing system has reduced normal maintenance to a few minutes every five years.

The eyebolt, large roomy conduit box and perma-numbered leads—"extras" at no extra cost—cut installation time to a minimum.

A new G-E oil field motor on your pumping rig is easily your most economical buy. Install it . . . forget it. For more information write for Bulletin GEA-6546 or contact your nearest General Electric Motor Distributor, or G-E Apparatus Sales Office. 877-1

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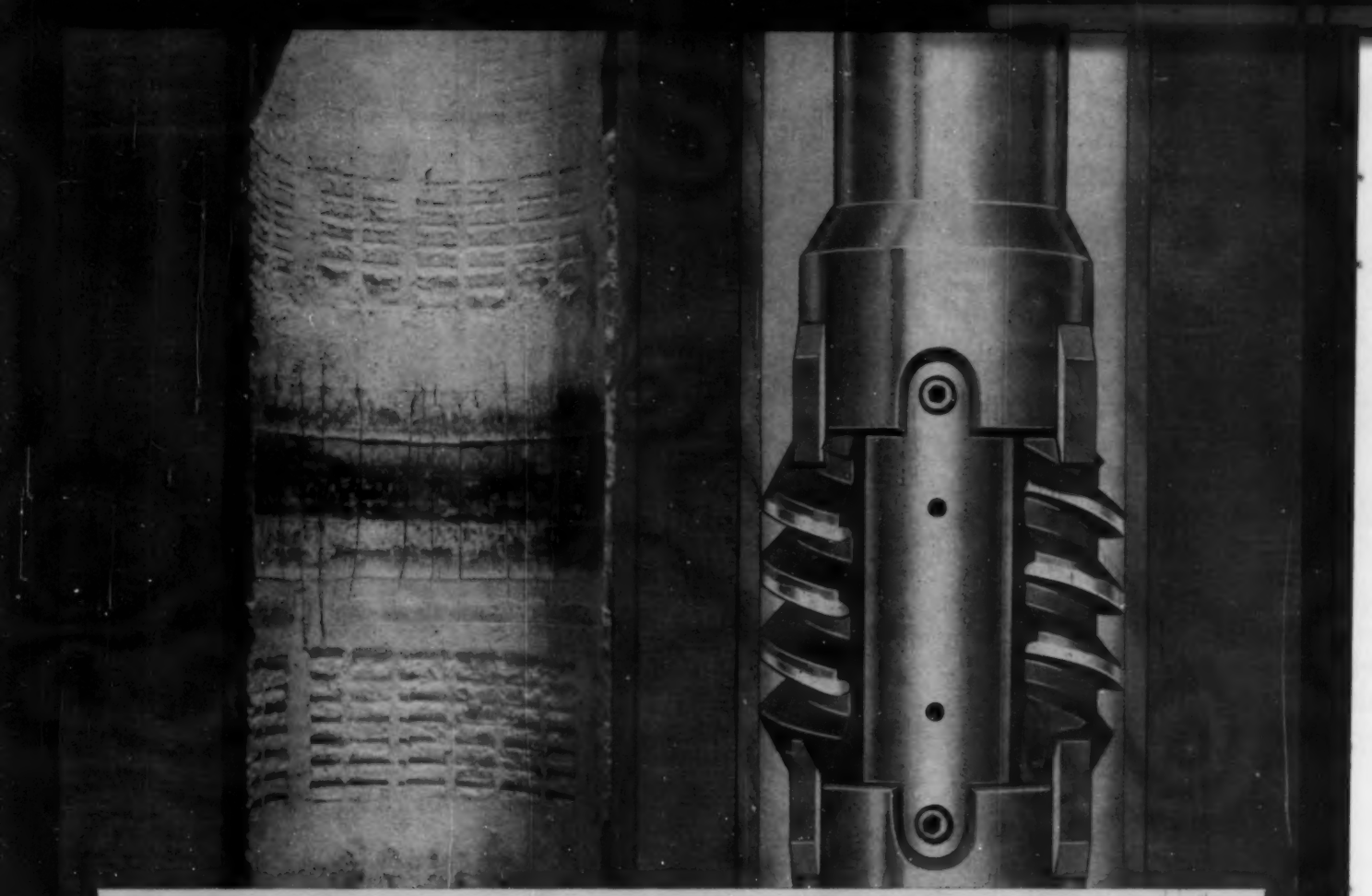

CAN YOU AFFORD *Not* to scrape your casing ...*the Baker way?*

You can't buy insurance for each job—so do the next best thing . . . keep your casing clean with the . . .

BAKER

This is just another way of asking "CAN YOU AFFORD THE EXPENSE OF DOWN-HOLE EQUIPMENT FAILURES?" The unretouched photograph at the above left provides visual proof of how casing neglect can cause even the best pack-off tool to fail.

In this case the pack-off tool set and packed-off perfectly—but the casing ID failed to do its part. Notice the cracks in the cement sheath in the area where the Packing Element was packed-off. *These cracks allowed the fluid under pressure to by-pass, even though the tool was securely set and completely packed-off.*

The Baker Roto-Vert Casing Scraper, which can be run on tubing, drill pipe or wire line, completely removes cement sheath and other obstructions such as perforation burrs and imbedded bullets—prepares the casing ID for subsequent work with pack-off tools. Remember, the condition of your casing ID is just as important to the successful operation of pack-off tools as the condition of a valve seat is to the operation of a valve.

Why take chances with so much at stake? The safe, positive, economical way to eliminate failures, such as the one illustrated above, is to make the running of a Baker Model "C" Roto-Vert Casing Scraper a part of your standard operating procedure.

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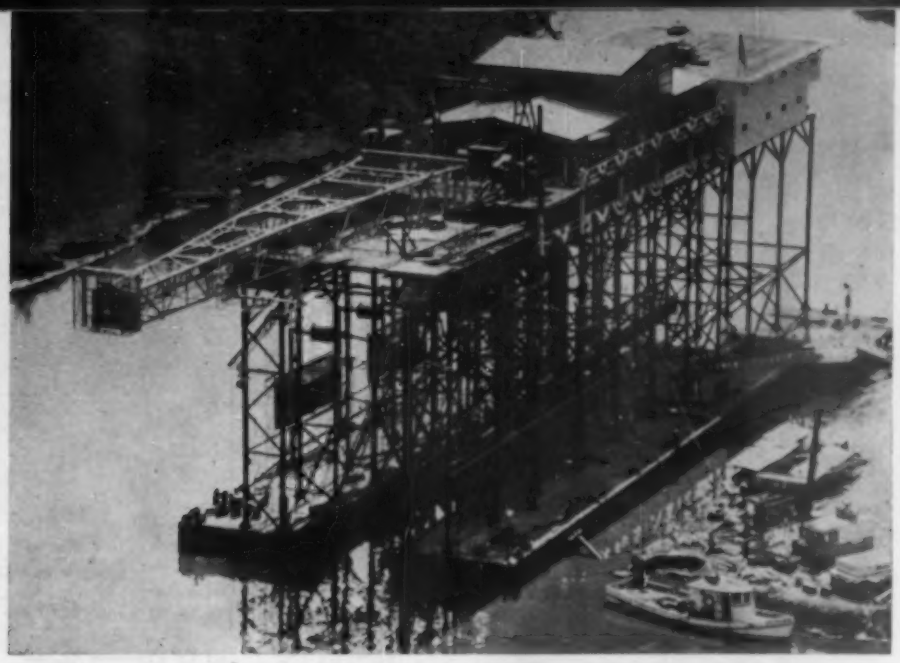
ROTO-VERT
CASING SCRAPER
PRODUCT NO. 620-C



Extending about eight stories high above water level in its floating position, the "Carter Mart" was completed in somewhat of a record time for a "giant" drilling barge like this. It is in the final completion stage.

P 422.912

Measuring 230 ft long, 75 ft high, rig capacity to 25,000 ft, Morris & Hamilton's "Carter Mart" is . . .

One of the GIANTS In Offshore Drilling Barges

3600 diesel horsepower drive entire rig laid out for utility, availability of all components

ONE of the largest drilling rigs ever assembled was mounted on a submersible barge measuring 230 ft long, 75 ft from barge bottom upper deck, 99 ft wide on one end and 75 ft wide on the slotted end. It is power-packed with 3600 diesel horsepower driving the entire rig . . . 2400 hp is available to the drawworks, reported to be the largest yet fabricated. On August 17, Platform Barge No. 12, or better known as the "Carter Mart" was dedicated by Morris & Hamilton, Inc., Houston drilling contractors, at Greens Bayou, near Pasadena, Texas. It is currently drilling its first well off the Louisiana coast for The Texas Company.

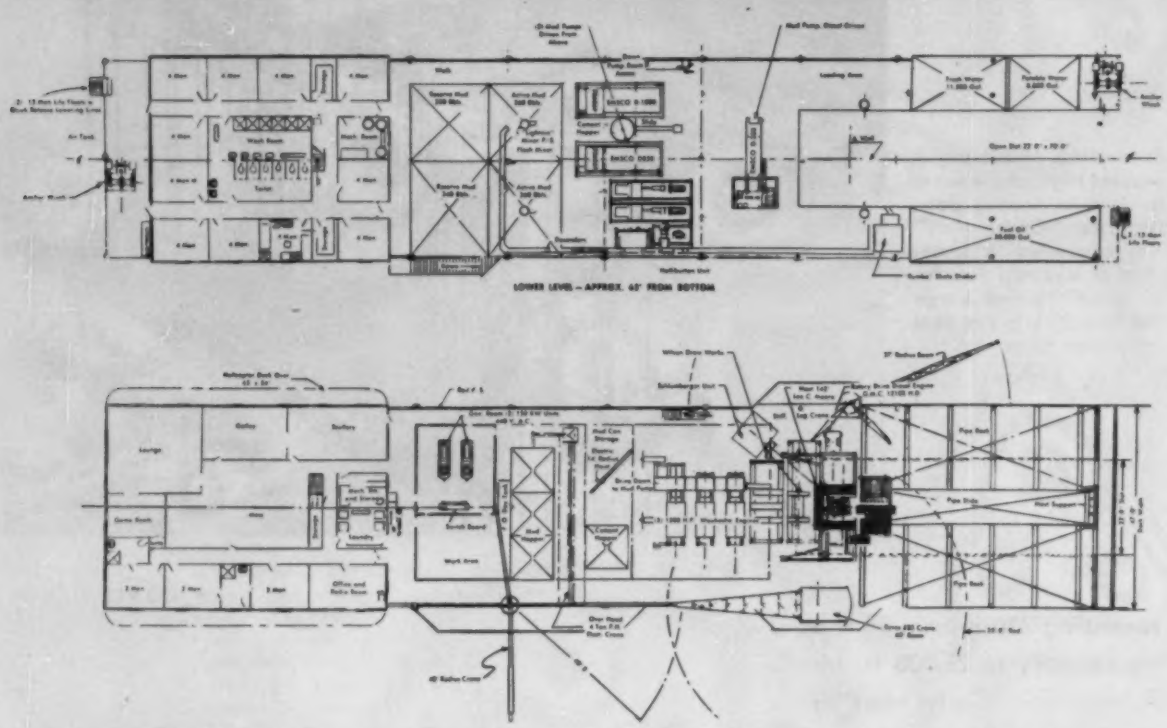
The cantilever type mast, traveling block, swivel and hook rigged with 1⅜-in. line have a capacity of 500 tons. The rig has been rated in the depth range of 20,000 to 25,000 ft.

The basic hull is 230 ft long, 99 ft wide at the aft end and 75 ft wide at the slot end, and 11 ft, 9 in. deep, with a 22 by 70-ft slot. Centrally located in the hull is a pump room adequately ventilated with a 6000 cu ft per minute blower. The pump room is accessible from the upper structure through a 4-ft diameter, water-tight, access tube. This pump room contains two, 1500-gpm ballast pumps, fresh water transfer pump, standby colling water and fire pump, two fuel oil transfer pumps and one sump pump.

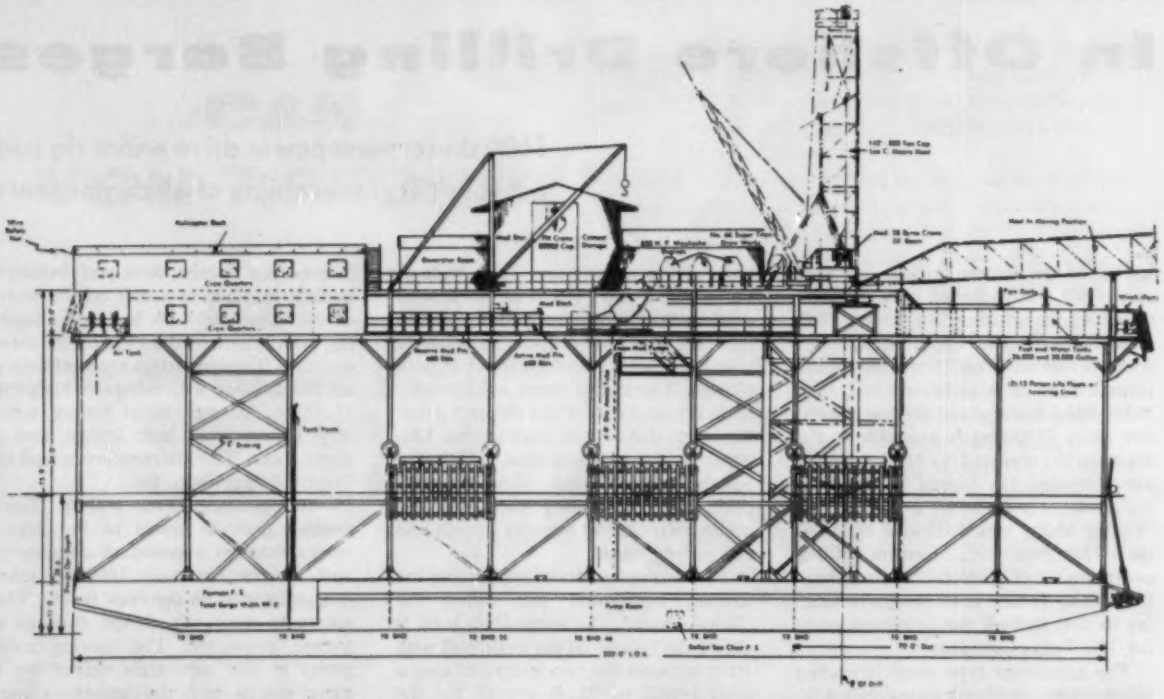
The two upper decks supporting the drilling equipment are called the "Texas Deck." The lower level is 65 ft above the bottom of the basic hull with 10 ft between the two levels, making a total height of 75 ft overall for the structure. The Texas deck is supported by 50 vertical columns adequately braced to withstand wind forces and wave action. Crew quarters, which accommodate 56 men, were prefabricated and set in place as a unit on the stern of the upper deck. A helicopter landing deck is provided on top of the crew quarters. These quarters are completely air conditioned with adequate sleeping facilities, showers, toilet rooms, scullery, galley, mess, hall, lounge, and a game room. The quarters are leased to Morris & Hamilton, Inc.

Power package. Three 800-hp diesel engines provide power to the drawworks through a powerful compound with drives for two 1000-hp mud pumps located on the deck below. The rotary is separately driven through a torque converter. The mixing mud pump is also separately driven by a diesel engine, as is the cementing unit. Electric power for the entire platform is furnished by two, 175-kw, 440-volt a-c generators driven by twin diesels.

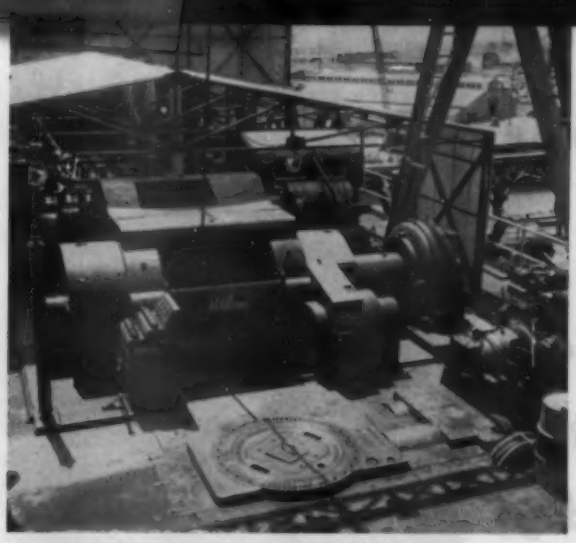
Mud facilities. Reserve and active



Floor plans of Texas deck, which includes both upper and lower decks. Equipment has been placed for maximum utility of space and ease of accessibility.



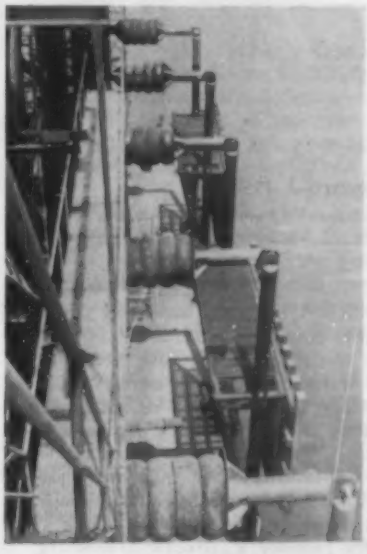
Elevation plan of the "Carter Mart" showing location of unique fender devices and cross bracing of supporting columns.



Floor view of M & H Platform Barge No. 12, showing giant drawworks and separately-driven rotary. For ample light and protection, much of the upper structure is covered with a corrugated glass fiber plastic which is green in color to filter out glaring sun rays.

Power compound and driving engines that transmit an available 2400 diesel horsepower to the drawworks or two 1000-hp mud pumps located on lower deck.

Storage and handling of dry mud is faciliated by three 1000-sack capacity hoppers from which dry mud is conveyed to a mixing hopper.



Unique fendering devices employ flexibility of large heavy-duty tires to absorb movement of vessels tied up along side drilling barge.

mud pits have a capacity of 1210 bbl. Electric-driven, vertically-mounted mud mixers are used in open pits on the second level of the Texas deck. There are three dry mud hoppers on the upper deck level behind the drive group with a total capacity of 3000 sacks of dry mud, or 1000 sacks per hopper. Mud is conveyed from the hoppers to a mixing hopper on the same deck. There is also a cement hopper with a capacity of 1000 sacks.

Drawworks. This unit has three forward speeds and reverse in an all-friction clutch transmission. Brake rings are 63-in. diameter and 10½ in. wide. It is equipped with a new braking system of the toggle or lever type. A hydraulic cylinder is connected to the brake system so that the brake can be engaged or disengaged in the normal manner. But, if the brake should suddenly be thrown back at high speed, a small valve in the hydraulic cylinder will close to prevent the lever from moving more than a short distance. It has a beam type equalizer in front of the drum and the entire assembly is pivoted on trunnions.

New idea in construction. A new method of construction was utilized in fabricating the platform, cutting about three weeks off completion time. In fact, it required only six months from the time the barge rig was ordered until it was completed and tested. The new idea in fabrication utilized the building constuction method known as "Lift-Slab." The upper structure was built on top of the lower hull deck near ground level. All equipment was set in place and the piping installed. Twenty-six of the 50 columns were utilized in hydraulically jacking this upper structure in two stages to its permanent position 65 ft above the barge deck. This idea is described in detail in another article in this issue.

Unique fending device. One of the problems in servicing offshore barges is that of securing vessels along side the platform so that wave action will not cause damage to either the structure or vessel. A unique fendering device was employed on the "Carter Mart" whereby large tires would serve as shock absorbers. Vertical members which support the timber fenders are hinged to the barge deck, and horizontal standoffs hinged to the top of these vertical risers. The standoffs include four large rubber tires which allow the fenders to give with wave action.

Name also unique. Somewhat of a precedent was set by naming Barge Platform Number 12 the "Carter Mart." It was named after a 5-year-old boy, Carter Martin Treadway, son of a close friend of the owners. ★ ★ ★

Monitor device accepts or rejects crude oil shipments to pipe lines according to limits dialed into it

BS & W Control In Automatic Custody Transfer

FIG. 1. Monitor and probe, as it is assembled in the meter house, inspects bs&w content of crude delivered from the separator and/or treating equipment to tankage, then actuates control valves to reroute crude to storage or through treating equipment.

Howard J. EnDean
Gulf Research & Development Company, Pittsburgh, Pennsylvania

ASSURANCE that crude oil delivered to custody tankage is within pipe line specifications for basic sediment and water has been one of the major problems in development of automatic custody transfer facilities. Reproducibility of dielectric constants of crude oil contaminated with water has enabled the use of capacitance-sensitive instruments as a solution.

The monitor, a capacitance-sensitive instrument is an adaptation of the capacitance product analyzer, successfully used in pipe line and production operations for batch interface and bs&w recording. In custody transfer applications, the monitor continuously inspects the bs&w content of crude oil being delivered from the separator and/or treating equipment to tankage. On exceeding bs&w specification, the monitor will actuate control valves to reroute crude to wet oil storage or through treating equipment.

The monitor assembly, Fig. 1, includes a pipe line probe and a control instrument. The probe is illustrated in Fig. 2. Essentially, it is a fixed capacitor, sensitive to changes in dielectric constant of materials passing between the centrally located electrode and wall of the surrounding pipe.

Fig. 3 shows the control instrument. Setting of the bs&w "limit dial" determines the bs&w content that will energize the control relays. The time delay unit shown at the right can be set to allow a limited quantity of contaminated crude oil to be passed to tankage where such deliveries are acceptable. Push buttons labeled "current level check" and "operation check" are for checking instrument operation and calibration.

The "current level adjust" dial, when used in conjunction with the "current level check" button, determines condition of the one radio tube in the assembly, indicating when replacement is desirable.

The plug above the "zero adjust" label protects the calibration adjusting screw. Rotation of this screw shifts the calibration of the instrument to match the crude oil of a specific installation.

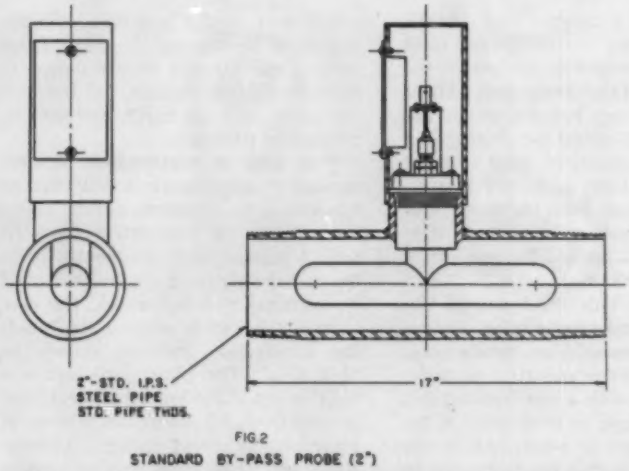


FIG.2
STANDARD BY-PASS PROBE (2")

FIG. 2. By-pass probe is essentially a fixed capacitor, sensitive to changes in dielectric constant of materials passing between the electrode and the pipe wall.

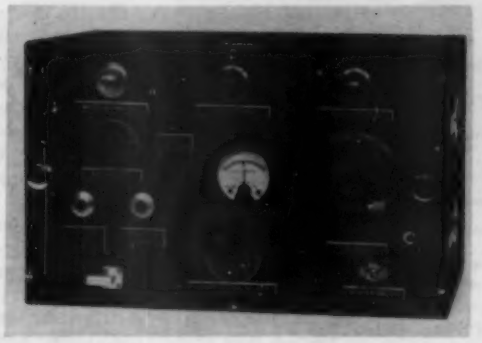


FIG. 3. Front panel of monitor consists of the bs&w limit dial, the time delay unit and current level adjust dials, three pilot lights showing stage of operation and whether crude is within established limitations. Push buttons are used to check instrument operation and calibration and condition of the one radio tube in the assembly.

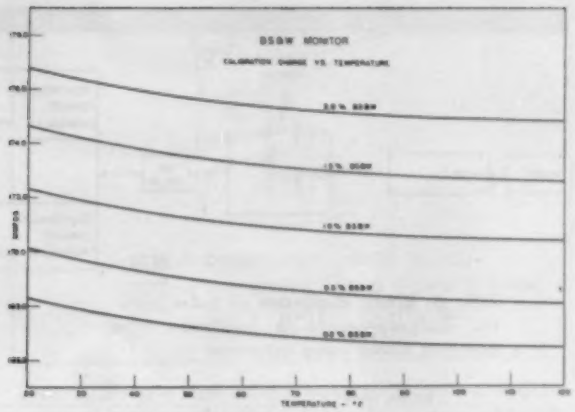


FIG. 5. Effect of temperature variations on monitor calibration. Tests indicate that with seasonal adjustment, operation over a 0 to 3 per cent bs&w range will be accurate to ± 0.1 per cent bs&w.

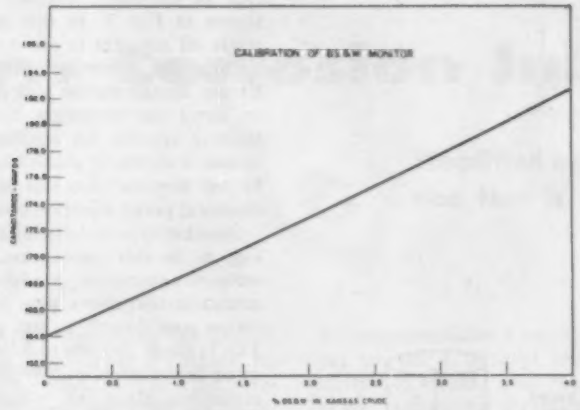


FIG. 4. Typical calibration of the monitor shows bs&w content in Kansas crude. For bs&w ranges up to 5 per cent, instrument response is essentially linear.

Three pilot lights located at the top of the instrument show whether the crude is within specification and what operation is taking place.

In a standard installation, the following would be an operating sequence. With acceptable crude oil being delivered to tankage, the pilot labeled "merchantable oil" would be lighted. When the setting of "bs&w limit dial" is exceeded, the "merchantable oil" light goes out, and the "excess bs&w" light and time delay unit are energized. If delivery of contaminated oil continues beyond the time delay setting, the "excess bs&w" light is extinguished and the "oil by-passing" light is energized. At the same time, relays are energized for valve operation and the warning light shown on the gooseneck of Fig. 1 is lighted. When oil passing through the probe is again within specification, the relay controlled valves direct crude oil to tankage and the monitor is automatically reset.

The range of the monitor shown in Fig. 2 is 0 to 3 per cent bs&w with 0 to 60-min time delay.

A typical calibration is shown in Fig. 4. For bs&w ranges up to 5 per cent, instrument response is linear.

The effect of temperature variations on monitor calibration is illustrated in Fig. 5. In developing data for this figure, both probe and instrument were subjected to the temperature variations indicated. These test conditions are of maximum severity, since in most operations, crude oil temperature variations will be less than atmospheric. On the basis of these tests it is anticipated that with seasonal adjustment, operation over a 0 to 3 per cent bs&w range will be accurate to ± 0.1 per cent bs&w.

The monitor system is illustrated by the block diagram, Fig. 6. The instrument employs a crystal oscillator whose plate-parallel-tuned circuit consists of a probe (cylindrical capacitor) in parallel with a variable capacitor (adjusted by the "bs&w limit deal"), and a fixed inductance. A discontinuity or step takes place in the tube d-c plate current when the plate-tuned oscillator goes into, or out of, oscillation as a result of a change in the tuning of the plate circuit. This tuning is accomplished by the varying bs&w contamination passing through the probe.

With the tuned-plate circuit inductive compared to the natural frequency of the crystal (probe capacitance is small), the d-c plate current flow is low. As the probe capacitance is increased beyond the control point setting, the tube snaps out of oscillation and the d-c plate-current abruptly increases. A current-sensitive d-c relay on the tube plate circuit is energized by the abrupt increase in d-c plate current. This relay then energizes a time-delay component. If basic sediment and water contamination persists beyond

The Author

Howard J. EnDean attended Purdue University and Carnegie Institute of Technology, receiving a BS degree in metallurgical engineering in 1938. Since graduation, he has been employed successively by Standard Oil of Indiana, Engineering Laboratories, Inc., and Gulf Research & Development Company, his present employer, in the fields of drilling, production, pipe line, and reservoir engineering, with particular reference to the instrumentation and equipment associated with these four fields.

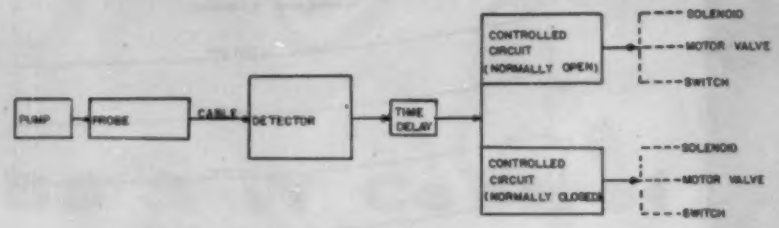


FIG. 6. Block diagram of bs&w monitor illustrates steps in operation from pump to motor valve actuation.

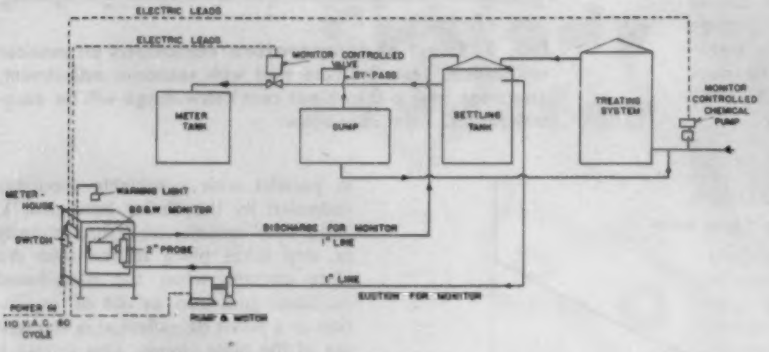


FIG. 7. Schematic of the monitor's application in lease automatic custody transfer. In this particular arrangement, crude oil adjacent to the outlet of the settling tank is continuously inspected.

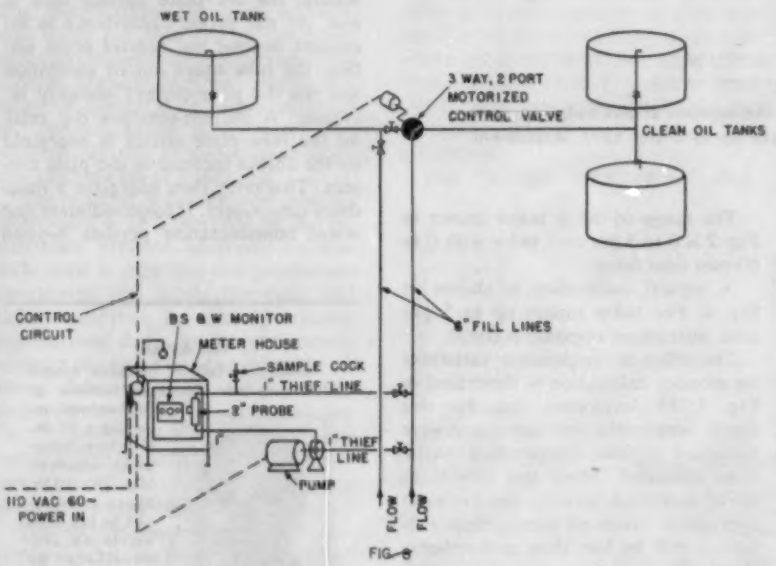


FIG. 8. Control of clean oil at unattended discharge station is illustrated in this schematic diagram. Clean oil is bypassed into storage tanks; oil continuously producing bs&w contamination above pipe line specification goes directly to wet oil storage.

the time setting, circuit control relays are actuated. When bs&w is reduced below the control point indicated by the "limit dial," oscillations are resumed and the d-c plate current decreases. This de-energizes the d-c plate circuit relay which in turn de-activates and automatically resets the time-delay mechanism.

How the monitor is applied to an automatic custody tank battery will depend upon arrangement of equipment and the function to be performed by the instrument. It is anticipated that a by-pass type probe arrangement will be standard since it maintains turbulent flow in the probe and assures thorough mixing of fluids. This arrangement also permits maximum flexibility since the monitor may be placed at any location convenient to operations.

Application of a monitor in one type of automatic custody battery is shown in Fig. 7. In this installation, crude oil adjacent to the outlet of the settling tank is continuously inspected. Excess contamination will be directed to sump for rerouting through the treating system. An auxiliary control system is shown by dashed lines whereby the monitor also can be used for chemical pump injection control.

Another type installation is shown in Fig. 8. In this application, oil from wells continuously producing bs&w contamination above pipe line specification goes directly to wet oil storage. This tankage delivers to a centrally located dehydration unit. Wells normally producing clean oil, which may at times produce water in excess of requirement, are directed through the line incorporating the monitor by-pass. When contaminated oil exceeds monitor setting for bs&w, the motorized control valve directs the non-specification crude oil to the wet oil tank. Rerouting to clean oil tanks will be automatic when bs&w content is reduced to specification.

The first monitor installation for bs&w control in an automatic custody tank battery has been in operation for approximately eight months. Several other installations have been made, with every indication to date that the instrument will meet industry requirements. The device in its present form meets specifications for bs&w control in the API informational bulletin on Automatic Custody Transfer. The monitor was developed and patented by Gulf Research & Development Company.

While developed primarily for bs&w control in automatic custody tank batteries, the monitor is adaptable to any process where changes in dielectric constant of fluids are suitable for control purposes. ★ ★ ★

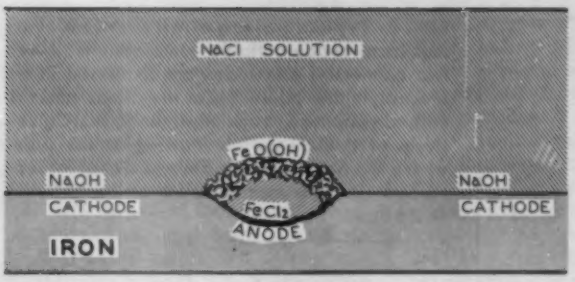


FIG. 1. Typical cathodic reaction is the formation of hydroxyl ions by the combination of oxygen and water. Iron goes into solution at the anode while basic NaOH is formed at the cathode, in a salt water solution containing dissolved oxygen.

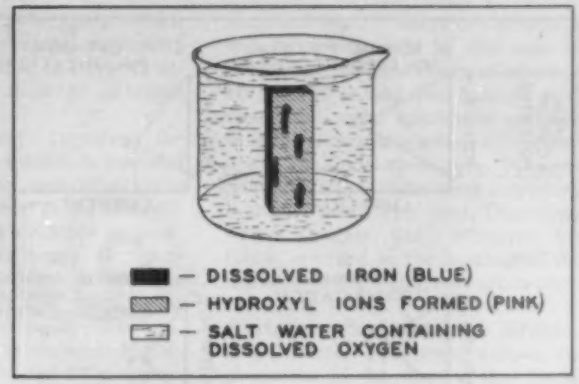


FIG. 2. Simple test using ferroxyl indicator shows occurrence of local anodes and cathodes on a metal specimen.

So, you've always wanted to know . . .

How Corrosion Inhibitors Work

Simplified explanation of a complex chemical reaction that is saving the industry millions annually

P. D. Muir
Dowell, Inc.,
Tulsa, Oklahoma

BASICALLY, corrosion consists of an exchange of electrical charges, resulting in the conversion of solid metal into soluble ionic condition. An understanding of the nature of corrosion must necessarily precede a discussion of the theories of corrosion inhibitors.

It has been established definitely that corrosion in aqueous solutions is electrochemical in nature. When electrochemical corrosion occurs, there must be an anode and cathode, and chemical reactions occurring at these two areas. The reaction occurring at the anode, known as oxidation, is the change from an uncharged metal atom to a positively charged metal ion in solution. This leaves negative charges (electrons) that migrate through the metal to the cathode. Here a second reaction takes place in which the excess electrons are transferred to some chemical in the solution, a process known as reduction. One common reaction occurring at the cathode is the reduction of hydrogen ions to hydrogen atoms. Another typical cathodic reaction is the formation of hydroxyl ions by the combination of oxygen and water. This is illustrated in Fig. 1.

The fact that anodic and cathodic areas exist, even on a piece of steel that has no visible surface differences, can be demonstrated by a simple test, making use of a ferroxyl indicator described by Evans.[1] This indicator contains potassium ferricyanide and phenolphthalein. When steel is immersed in a salt water solution containing oxygen and this indicator, the cathodic areas turn pink due to the formation of hydroxyl ions (phenolphthalein turns pink in the presence of bases). The anodic areas turn blue due to iron going into solution, potassium ferricyanide being an indicator for dissolved iron. This is shown diagrammatically in Fig. 2.

Such corrosion will occur continuously until something happens to stop it. For example, if a piece of iron is coupled electrically to a more reactive metal such as magnesium, then the entire iron specimen becomes the cathode, and corrosion of the iron is halted. The magnesium in turn becomes the anode, and as such, corrodes or goes into solution, protecting the iron.

Anodic and cathodic areas on a metal specimen can change during the corrosion process. Usually steel will, if cleaned before immersing in a corrosive medium, corrode fairly uniformly over the entire surface. This would indicate that the cathodes and anodes are moving or changing places during the corrosion.

The electrochemical theory of corrosion states that the quantity of electricity, flowing between such anodes and cathodes, is proportional to the amount of metallic corrosion, in accordance with Faraday's law. If the potential of the anode or cathode is measured against a reference electrode, the potentials of the anode and the cathode can be determined. The difference between these potentials is termed the open circuit potential and may be expressed as shown in Fig. 3.

When two connected electrodes are immersed in an electrolyte, the potentails of the anode and the cathode approach each other along some given slope of a line as in Chart I, Fig. 3. This shifting of the electrode potentials towards each other is termed polarization. Current flowing at the point where the two potentials become equal (a) represents the maximum amount of current that could flow. The magnitude of this current determines the maximum amount of corrosion that could occur. Actually the two potentials probably never quite meet because of the potential difference due to the IR drop caused by the corrosive medium.

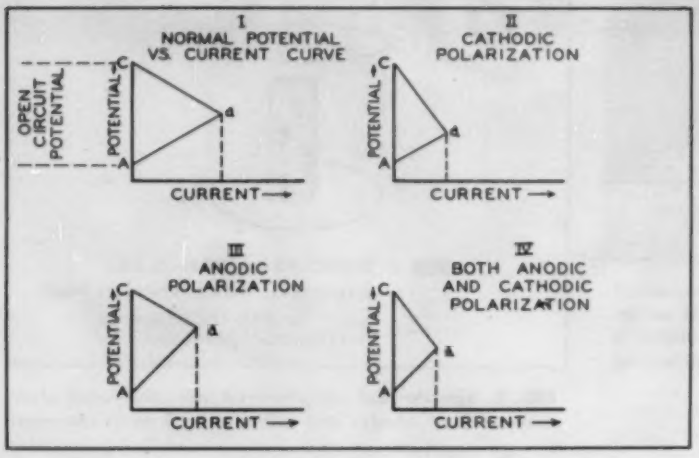


FIG. 3. Typical polarization curves for various local anode-cathode combinations. When two connected electrodes are immersed in an electrolyte, the potentials of the anode and the cathode approach each other along some given slope of a line. Current flowing at the point where the two potentials become equal (a) represents the maximum amount of current that could flow.

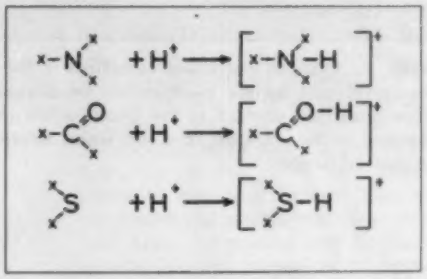


FIG. 4. Certain organic semipolar compounds have a tendency in acid solutions to form ions of the ammonium, oxonium, or sulfonium type, as illustrated in these chemical formulas.

Anything that can be done to increase the polarization of either the anode or the cathode will decrease the corrosion. For example, if the slope of the cathodic potential vs current is made steeper, the corrosion will decrease (Chart II, Fig. 3.) Similarly, if the anodic potential vs current is made steeper (Chart III, Fig. 3) the corrosion is decreased. If both become polarized, even less current will flow, resulting in further reduction in corrosion (Chart IV, Fig. 3).

This is a brief description of the electrochemical theory of corrosion. It is the basis for many theories on corrosion inhibitors, and is the basis for most cathodic protection systems.

Inhibition by Anodic Polarization

The main reaction taking place at the anode is the solution of metal. These metal atoms give up electrons as they go into solution. These metal atoms in solution are then positively charged. The valence of the metal determines how many electrons it will give up. For iron, which is the metal usually involved in corrosion problems, this is usually two. In other words, for each atom of iron going into the solution, two electrons are given up. These electrons are transferred to the cathodes through the metal and are there consumed by reactions occurring at the cathode.

Any corrosion inhibitor that slows down the anodic reaction causes anodic polarization, and the potential of the anode approaches that of the cathode more rapidly, reducing the amount of current flowing. Inhibitors that cause anodic polarization are classified by Evans[2] as anodic inhibitors.

In most systems, if the amount of current flowing (and the accompanying corrosion) is reduced by polarization of the anodic areas, it is important that enough anodic inhibitor be used to provide complete protection. Otherwise, the current will be concentrated as relatively small unprotected areas, and intense localized corrosion and pitting may take place. For this reason, anodic inhibitors often are classified as dangerous inhibitors,[2] and should be used only in a closed system (such as a cooling system) where a high concentration of the inhibitor can be maintained. Examples of anodic inhibitors are inorganic salts, such as chromates, phosphates, carbonates, or silicates.

Inhibition by Cathodic Polarization

The principal reaction occurring at the cathode in a conducting solution is the discharge of electrons from the metal to an ion in solution. For example when iron is immersed in an acidic conducting solution, the main cathodic reaction is the reduction of hydrogen ions, so that they become hydrogen atoms, according to the following equation:

$$2H^+ + 2e^- \rightarrow H_2$$

In a neutral or basic system containing oxygen, the main cathodic reaction consists of oxygen combining with water and the excess electrons to form hydroxyl ions, according to the following reaction:

$$\tfrac{1}{2}O_2 + H_2O + 2e^- \rightarrow 2\ (OH)^-$$

Of course these are not the only reactions that can take place at the cathode. Hydrogen and oxygen reactions are two of the more common ones, however.

The control of corrosion by cathodic inhibitors (i.e., those that stifle the reaction at the cathodic areas) is usually considered as *safe*,[2] in contrast with the anodic type inhibitors. Thus, even though conditions might result in insufficient inhibitor being present to afford complete protection, the resulting corrosion will be distributed uniformly over the entire anodic surface, rather than being concentrated into a few restricted spots and thus intensified.

Mechanism of Inhibitor Action

Corrosion inhibitors may be classified in a number of different ways, depending on their composition and how they function. Basically, they can be divided into two main classifications: Inorganic and organic.

Inorganic Inhibitors

The inorganic inhibitors may be subdivided into anodic and cathodic inhibitors, by their action. Those inhibitors that retard the anodic reactions of corroding metals are classified as anodic inhibitors. Some typical ones are sodium chromate, sodium dichromate, sodium hexametaphosphate, sodium nitrite and sodium silicate. These usually act as anodic inhibitors, although in some instances they may serve as cathodic inhibitors as well. There are two main theories regarding the manner in which inorganic anodic inhibitors function: One, by the formation of a protective, insoluble film on the metal; the other, by the adsorption of chemisorption of the inhibitors onto the metal surfaces. According to Evans,[2] most sodium or potassium salts, containing anions which form a sparingly soluble salt with the metal under consideration, act as anodic inhibitors. For instance, sodium phosphate in neutral or alkaline solutions acts by the precipitation of iron phosphate at the anode, where the iron dissolves. In a similar manner, some of these inorganic inhibitors cause a thin protective film of iron oxide to form on the surface of the steel.

A theory that the precipitation of a film, such as iron oxide or iron phosphate, is not necessary for inhibition, although such a film may help the overall protection, is subscribed to by Uhlig.[3] According to this theory, inhibition by chromates and other oxidizing inhibitors is due primarily to physical and activated adsorption-chemisorption. The metal atoms remain in place on the metal, but since these have valence forces which need to be satisfied, negative ions, such as chromates, are adsorbed to the metal and form surface compounds in place.[4] This is in contrast to the precipitation of a film, by dissolved iron reacting with an anion and then being deposited on the metal. Of course, both systems can operate in the same medium.

The Author

P. D. Muir is a development engineer for Dowell, Inc. He was graduated from the University of Arkansas in 1942 and joined Dowell in 1946 after serving four years in the army. As a research chemist for six years, he assisted in the development of several corrosion inhibitors. Since 1953, he has been engaged in development work with corrosion inhibitors for down-well treatment of oil and gas wells.

Inorganic cathodic inhibitors are those inhibitors that slow down the cathodic reaction. Typical cathodic inhibitors for iron, in neutral solutions containing oxygen, are salts of zinc and nickel. The action of these materials is probably due to their forming insoluble hydroxides at the cathodic areas where hydroxyl ions are formed.[2] Salts of arsenic and antimony act as cathodic inhibitors in acid solutions. It is believed that these are plated onto the cathodic areas as free metal and decrease the hydrogen evolution, thereby limiting the corrosion.

Organic Inhibitors

Most of the inhibitors in use to prevent oil well and refinery corrosion are organic inhibitors. Generally speaking, the organic inhibitors do not undergo chemical changes during inhibition, whereas many of the inorganic inhibitors do.

Inhibitors of the organic type are, almost without exception, compounds containing elements of the fifth or sixth groups of the periodic table. Most of these inhibitor contain sulfur, oxygen, or nitrogen.[4] Such organic inhibitors usually consist of a polar group (which is the end of the molecule containing either nitrogen, sulfur or oxygen) attached to a long chain of saturated hydrocarbons.

A popular theory, regarding the functioning of such inhibitors, has been that these organic semipolar compounds were adsorbed at the cathodic areas. Considerable evidence is available to support this theory. One particular theory is that such compounds have a tendency in acid solutions to form ions of the ammonium, oxonium, or sulfonium type, as shown in Fig. 4. Mann and his co-workers[5, 6, 7] proposed that in this ionic form, the inhibitors are attracted to and adsorbed at the cathodic areas, since these areas are negatively charged. Since they cannot be electrically discharged (as hydrogen could be, for example) they remain adsorbed and prevent hydrogen ions from discharging at the cathodes, thus inhibiting corrosion by cathodic polarization. Mann and his co-workers showed that inhibition increased with chain length and cross section of the molecule, and several other investigators supported Mann's conclusions.

Recently, the theory of cathodic adsorption of inhibitors of this type has been questioned. Hoar[8] has observed a shift of the electrode potential toward more cathodic values which would indicate anodic polarization, or that the inhibitors were being adsorbed anodically. Other studies have shown both anodic and cathodic polarization with these inhibitors indicating overall general adsorption. Hackerman and Makrides[9] proposed that adsorption takes place generally, rather than specifically at either anodic or cathodic areas. One explanation is that, like the theory mentioned on inorganic inhibitors, the surface of the metal has some valence forces that must be satisfied. Thus, it may be that the binding force responsible for the strong attraction of these inhibitors is the formation of a dative bond between the metal and the organic molecule. Such bonds are formed through sharing a pair of electrons between the inhibitor and the metal. This has been postulated by George and Hackerman.[10]

Laboratory studies have shown that any inhibitors are adsorbed very strongly. For example, George and Hackerman[10] made studies in which inhibitors were adsorbed from benzene solutions onto metal coupons. The specimens were then washed with fresh benzene and placed in hydrochloric acid solutions. The investigators found that many inhibitors continued to furnish protection, even though there was no opportunity for replacement of the inhibitor. Many others have made similar studies. One good example is the proposed NACE laboratory screening test for inhibitors.[11] In this test, oil soluble organic inhibitors are adsorbed during a 10 second time interval, after which the metal specimens are subjected to a corrosive solution for seven days. The protection given by some inhibitors tested under these conditions is greater than 90 per cent. These tests would indicate that, whatever the forces involved in the holding of the inhibitor on the metal, they are in some cases very strong.

Another illustration that inhibitor film is firmly held, even without replacement of the film, is that many producing wells are now being treated with organic inhibitors only once or twice a week, yet these wells are being protected from corrosion during the interim between applications. Experiments, made in pumping wells, have indicated that the inhibitor, in most cases, comes in contact with rods and tubing for only a relatively short interval of time. Since protection is maintained between treatments, it follows that the adsorbed film must remain tightly held for some length of time. Extensive research study is in progress to find materials with even stronger attractive forces than those presently being used.

Summary

There are several theories regarding the manner in which inhibitors function. In many inhibitors, a general adsorption, cathodic and anodic adsorption, chemisorption and physical adsorption, and preferential oil wetting, probably all combine to provide the corrosion protection. These mechanisms can reinforce each other and in most inhibitor applications, it is believed that more than one mechanism is involved.

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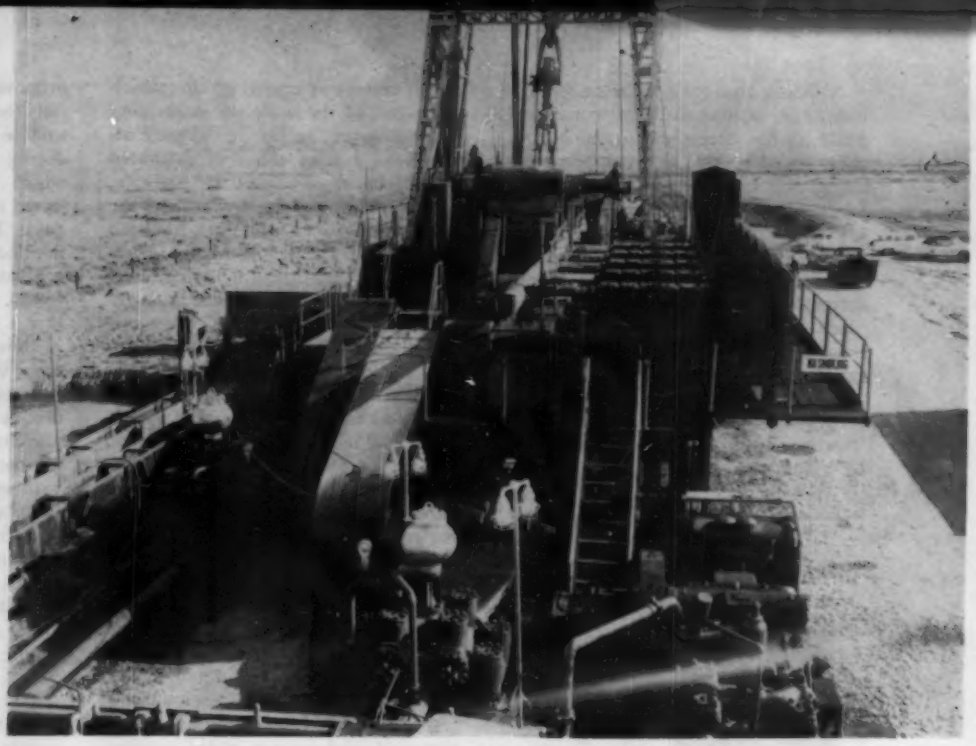
Acknowledgment

This paper was presented at the Corrosion Control Short Course, sponsored by the University of Oklahoma at Norman, April 3-5, 1956. It has been released for publication by the National Association of Corrosion Engineers. ★ ★ ★



Neatness is the middle name of Rocky Mountain Drilling Company's new Rig 5. The new 15,000 ft depth-rated unit combines many of the latest time and space-saving features to put it at the head of the list of California deep rigs.

New West Coast rig has

Latest Ideas in Rig Hookups

Rocky Mountain's Rig 5 features:

- **Higher mast**
- **Enclosed substructure**
- **Common engine exhaust**
- **Central lubricating system**
- **Permanent BOP control system**

EXCLUSIVE

Jerry Stumm

UNITIZATION in drilling rig construction is assuming new meaning for Rocky Mountain Drilling Company, Los Angeles, California. Recently completed Rig 5 is an outstanding example of the trend in the multiple grouping of rig components. This handsome new rig incorporates several design features that fulfill the demands of modern rig construction — compactness, minimum weight, greater accessibility for maintenance, fast rig-up and tear-down facilities, while still maintaining the basic requirement of a powerful rig providing maximum mud volumes.

Rig 5 was specifically constructed to meet Rocky Mountain's needs for a flexible unit able to move in and out of the less accessible California areas of exploration and development. The rig was put together in the company's Ventura yard under the direction of Elmer V. Kimble, superintendent.

Mast

Rig 5 stands a head higher than most rigs in its depth classification of 15,000 ft. The mast is a heavy duty cantilever type unit with 900,000 lb capacity. An additional 8-ft section was placed in a standard 142-ft mast to facilitate the use of a 100-ft kelly joint, developed by Rocky Mountain Drilling Company personnel and now used as standard equipment.

Substructure

A 14-ft base, on which the draw-works and mast sit, adds increased height to the towering mast to offer several unique and useful features. The height of the substructure permits plenty of headroom to install blowout equipment without deep cellars, with additional room to install more control equipment if necessary.

The main base breaks into two units

for moving. The top section rising 5 ft and 2 in. above the 8 ft by 10-in. subbase, is bolted at recessed pockets to provide a smooth and protected exterior surface area. All electrical connections are placed in the substructure in a similar manner as a safety precaution.

The engine base rises 8 ft and 10 in. above the ground level and is fastened to the 14-ft high main section with four 2-in. pins extending through each base. These combine the two bases into one integral unit providing additional strength for lowering and raising the mast and distributing the load for rated depth drilling.

Both sides of the substructure are completely enclosed. On the driller's side of the main base is a room housing an electrically driven air compressor, the air receiver tank, a water pressure pump and six oil pressure tanks. Each of these hold 100 gal of fluid and contain all the various lubricating oils required for the operation of the rig. These oils are pressure fed to a series of valves conveniently located on the floor of the engine base near the No. 1 engine. A 2000 psi nitrogen bottle is located here for the emergency operation of the air clutches.

On the opposite side of the substructure is a 125-bbl tank to supply water for the operation of a 60-in. single-stage hydromatic brake. A centrifugal mud hog and one low and one high pressure electrically driven pumps are positioned here. These have been manifolded together for operation of the pressure system.

Below the 8 ft, 10-in. high engine base is a replacement parts storage area and tool house.

The walk-way and guard rails in front of the engines fold up to each engine in individual segments that anchor directly to the engine radiators. All guard rails on the substructure are hinged to the floor and are permanent installations requiring no dismantling.

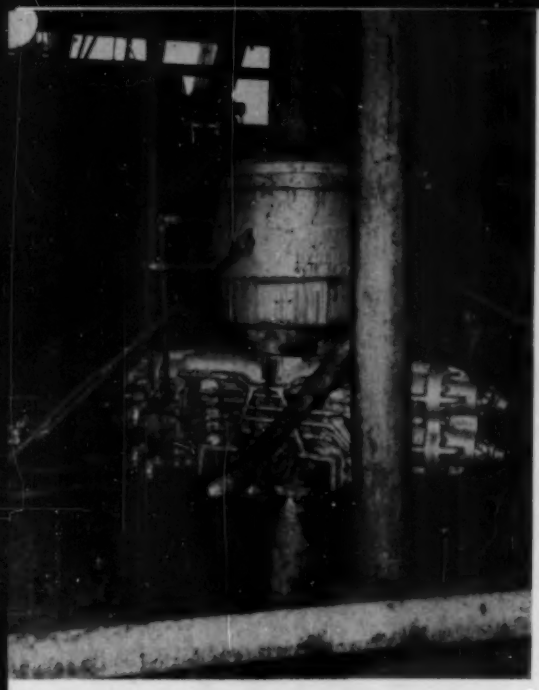
Blowout control wheels are mounted permanently in the substructure. Slide extensions have been provided to adjust the shafts for various heights of blowout preventer equipment.

Suspended from and attached to the substructure wall on the driller's side is the drilling line spool. The spool is held by two large turnbuckles so that the spool can be rolled to the side of the rig, a pipe is inserted through the center of the spool and lifted off the ground. Horizontal pipes extending out from the side of the base and hinged for vertical movement, hold the spool away from the base so that it is free to revolve as additional line is required during the drilling operation.

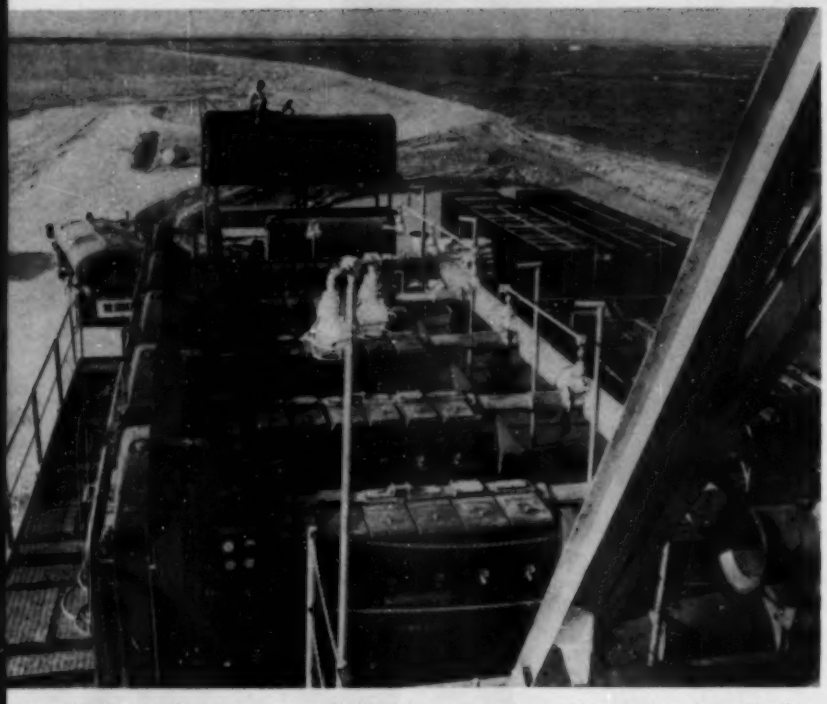
Totally enclosed substructure of Rig 5 provides ample space for oil and air pressure tanks, mud hog, a water tank, pressure pumps and compressors, tool house and replacement parts area.

G. O. Worley, vice president of Rocky Mountain Drilling Company, is seen here ascending the stairway to engine base. Note recessed bolts and pins permanently mounted to blowout control wheels.

Main substructure houses six 100 gal oil tanks, left, which pressure feed lubricating oils up to point-of-use locations on the engine level.



Blowout control equipment installation has been eased considerably by the ample working area below the 14-ft high substructure.



Engine exhausts are manifolded into a common exhaust pipe through vibration-free flexible pipe. Note the diesel fuel tank at top center.

Exhaust System

One of the most unique features of the rig is the exhaust system. The five 370-hp engines are serviced by a common exhaust permanently positioned above the engine compound. This manifolding has proved to be quieter, as well as having the additional advantage of ease of rigging up and tearing down. Only one water inlet is required to control the exhaust cooling water for all five engines. Three baffles near the outlet end of the exhaust provides ample muffling, and a 1-in. water inlet with a 3-in. outlet allows a fan-tail spray to fall on the baffles for fire hazard elimination. Blinds are provided at the connecting flange of each exhaust that can blank off any engine from the main exhaust should repair work be required on an engine while the rig is in operation. Flexible pipe has been installed successfully between each engine exhaust and the main exhaust to absorb vibration.

Power Transmission

A special five-engine compound ties the engines together as a unit so that all engines can be used for hoisting with the drawworks. During normal drilling operations, four engines drive the 8½ by 16-in. tail pump and one engine drives the rotary table. A 7¾ by 18-in. side pump is linked to the compound. Mixing pump, a 7¼ by 18-in. unit, is independently driven by a 130-hp diesel with torque converter. Total engine horsepower is 1980, providing a heat and compact rig "package" to meet the most stringent California deep drilling needs. ★ ★ ★

15 Firms Organize Petroleum Diamond Drilling Association

Widespread use of full-diameter, diamond drilling and coring tools, has led to the organization of the Petroleum Diamond Drilling Association, a group of companies engaged in the design, manufacture, and sale and service of this special equipment.

Industry-wide in representation, the 15 companies that originally formed the association have set up committees for the study of various problems including federal, state, and local taxes; accounting procedures and practices; standardization of diamond drilling and coring terms; and transportation and salvage. Other pertinent topics under consideration are the latest trends in diamond bit design; standardization of core barrel parts; credit procedures; publicity and customer relations, and special industrial insurance.

Officers of PDDA are J. C. McNeal, Hillmac Corporation, Midland, Texas, vice president; Carroll Deely, Drilling and Service, Inc., Dallas, Texas, president; C. C. Miller, Diamond Contractors, Ltd., Dallas, secretary-treasurer, and Ed Williams Jr., Williams Bit and Tool Company, Greenville, Texas, vice president.

Other members of the association include Bert Sutton Jr., P&S Engineering Company, Bartlesville, Oklahoma; Clyde Foster, Foster Diamond Coring Company, Arkansas City; Jake A. McCallister, Diamond Bit and Coring Company, and Graham Diamond Coring Service Corporation, Victoria, Texas; J. R. Mayeaux, Hycalog, Inc., Shreveport, Louisiana; R. W. Stewart, Diamond Oil Well Drilling Company, Midland; Halbert Pierce, P-N Diamond Coring, Inc., Borger, Texas; Arthur W. Sour Jr., Diamond Coring Company, Shreveport; B. G. Harmon, DiKor Diamond Coring Service, Carmi, Illinois; Bennie R. Jones, Diamond Coring, Inc., Abilene, Texas; Patrick Adamson, Wheel Trueing Tool Company, Detroit, Michigan, and Barney Haffner, American Coldset Corporation, Paterson, New Jersey.

P 500.

CASING STRING DESIGN Handling and Usage

Largest material cost in the well installation is casing. These costs can be appreciably reduced by good casing design and application practice

J. W. Peret
Sun Oil Company, Dallas, Texas

CUT ALONG THIS LINE FOR YOUR PERSONAL REFERENCE FILE.

SUCCESS or failure of casing governs, to a great extent, the success or failure of the complete well operation. With advanced drilling depths characteristic of recent years, the validity of this principle has been highlighted by examples where the penalty of casing failure financially jeopardized the overall well installation.

Considering the large monetary outlays ventured, it is not excessive for management to ask that casing failures be eliminated and with the expectation that this goal will be substantially achieved.

The passing of each year has witnessed real advancements in tubular technology — combining superior pipe produced by the mills, along with the application of improved practices employed by the operators. It can be realistically predicted that with increasing well depths the operator will be faced with problems of greater complexity and with increasingly severe costs associated with failure. These conditions warrant the best possible considerations that can be given to design, handling, and usage, of casing strings.

Use of Casing Strings

Common practice has evolved the usage of five types of casing strings, dictated by well conditions and practices.

Conclusions

1. The multiple purposes of casing design include the provision for adequate tubular strength throughout the string to successfully oppose well forces, and, at the same time, effect economy in tubular investment as a measure to help control and suppress well costs.
2. For the deeper wells, which require special non-API casing of high strength, the prudent selection of appropriate casing, on a strength-cost relationship, can effect significant economy.
3. For the deeper wells with heavier casing loads, the design of the wellhead at the slip region assumes significant importance and merits careful consideration. Also, because of heavy loads, the casing supporting the bradenhead should be carefully considered and appropriately designed to fulfill strength requirements in order to avoid failure.
4. Limitations in the availability and operator's inventory of pipe stocks frequently exert an appreciable influence on the strings actually run as compared to those preferred by the dictates of design.
5. Where nonavailability enforces the use of strings of substandard strength, it becomes necessary for all personnel to have a thorough understanding of casing behavior in order to execute well completion operations (such as acidizing, swab down, etc.) and at the same time avoid the use of practices that would lead to casing failure.

Conductor String

Where the surface and upper layers are unconsolidated, such as loose gravel, loose sand, and swamp marsh, pipe is needed to stabilize the cellar floor and to restrain the hole walls down to the point where soil strength will be self-supporting and the hole wall will "stand up." Conductor strings serve these purposes, as well as to seal off shallow water flows and prevent loss of circulation for drilling at lower depths. These strings vary in length, ranging from one or two joints up to several hundred feet or more, depending on surface soil conditions.

Conductor strings may be bypassed entirely where local surface soil conditions do not require their use. Conventionally, 16-in. or larger casing is used.

Surface Strings

For wells of any appreciable depth surface strings are universally employed. The incidence of past-experienced trouble in the industry indicates that their importance is paramount.

The surface casing provides a foundation for, and support of, the wellhead, and is the tubular member to which the wellhead is normally attached, by welding or screwed connections. Since succeeding strings are landed in, and supported by the wellhead, it becomes apparent that the connection between the surface string and wellhead is often subjected to tremendous compressive loads. In event this compressive load exceeds the junction capacity, failure can be expected. Such has been experienced in the industry.

Sealing off of upper fresh water zones accomplished by surface casing is required by law in many localities to prevent contamination of fresh water sources. Upper gas charged zones should and can be sealed off by means of the surface casing.

While drilling ahead and advancing the hole toward total depth, horizons at lower levels are frequently encountered bearing gas pressure. Migration of this pressure upward must be successfully confined within the surface casing in conjunction with the blowout preventors. *Casing must be set sufficiently deep to exclude weak strata with insufficient strength to contain these pressures.*

The length of surface strings varies from several hundred to several thousand feet.

Protector String

In the event that no adverse drilling conditions are encountered, a protector string is not needed. Where adverse conditions do prevail prior to reaching total depth, control

is often best maintained by the use of a protector string. The applications of protector casing strings are as follows:

1. Salt water flows of large volumes may be sealed off to prevent invasion of the mud column.

2. Zones of "marginal balance" may be sealed off to permit uninterrupted and economical drilling progress. This refers to a combination of hole sections where the drilling fluid is either thiefed-off when mud weight is too great, or where gas pressure "kicks" when fluid weight is too light — all within a range of weight variation that is extremely small.

3. Surveys show a multitude of deviations in well crookedness caused by non-uniform formations, rotation of bit, buckling-induced inclination of the bit, insufficient drill collars, etc. Hence, dog-legs and other points of lateral contact exist between the rotating drill pipe and hole wall. Transmission of mechanical energy therefore occurs with resultant breakdown of hole wall. This allows heaving of the formation, causing "stuck" drill pipe. In event this occurs, well before reach total depth, a protector string is usually considered a necessity.

4. Occurrence of extensive salt beds, as in the Williston Basin area, presents a substantial problem. Dissolving of the salt by the drilling fluid causes caverns which later either cave-in or flow radially under overburden pressure and terminate in crushed casing along with external salt corrosion. Protector string is set as soon as possible to reduce extent of caverns and salt saturation in the drilling fluid. This casing also serves to protect inner casing string from salt corrosion.

5. After the hole is drilled to a considerable depth, the encountered pressure may materially exceed the confinement strength capacity of the surface casing or the open hole. In this event, a protector string is used to provide this increased strength in both resistance to collapse and burst.

Lengths of protector strings vary in accordance with depth locations of adverse drilling locations. Common lengths range from, say, 6000 ft to greater. The Gulf Coast has instances where 9⅝ casing was run, as protector strings, to around 14,000 ft, with string weights in the vicinity of 800,000 lb. Occasionally two protector strings are run. Such a requirement would and does exist where severe drilling conditions occur twice below surface casing before total depth is reached. Additionally, a second protector string is sometimes needed, in a smaller size, to replace the initial protector string that failed and could not be successfully repaired.

Oil String

As the hole is advanced and reaches the pay zone at total depth, the decision to run an oil string must be made.

- Where full technical information is successfully obtained in open hole conditions and which conclusively condemns a prospect, the cost of running an oil string is avoided.
- Where full information obtained in open hole indicates a producer, the oil string is run.
- Where full information indicates a borderline prospect, the need for a positive evaluation generally dictates running an oil string.
- Where open hole conditions are precariously unstable and preclude the running of tools to obtain technical information, an oil string is normally run to permit positive evaluation of the pay.

The oil string serves as a receptive encasement for tubing, packers, gas lift valves, pressure control devices and other down-hole tools, affording them protection from heaving hole walls, external corrosion, pressure, etc. It segregates multiple pay zones and prevents commingling of hydrocarbons as usually required by law and prudent operating practice. Additionally, other zones bearing water, gas, etc., would likewise be sealed off.

Where the oil string is set through the pay zone, precise perforating procedure permits selective production to better exploit the reservoir giving superior primary depletion and better secondary recovery performance.

Because of the oil string's reduced diameter, superior strengths may be employed in overcoming well forces which attempt to collapse or burst the pipe. Additionally, deeper setting depths may be achieved. The length of the oil string is determined generally by the depth of the lowermost zone that is considered a potential candidate for production.

Liner

A liner is an abbreviated oil string extending from the bottom of the hole upward to about 100 ft into the protector string, where it is suspended and sealed off. Its function is generally similar to that of an oil string. Being shorter than a full oil string, it provides economy because less casing is used.

Disadvantages of the liner are the possibility of leakage at the junction of liner top and protector string, permitting fluid flow, and that the protector string is exposed. Being a bigger string in diameter, the protector string cannot offer substantial strengths at economic costs. Further, external corrosion increases chances of failure and the possibility of

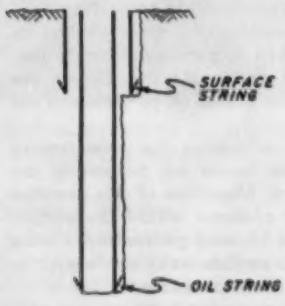


FIG. 1. Casing and hole program for mild or shallow drilling conditions.

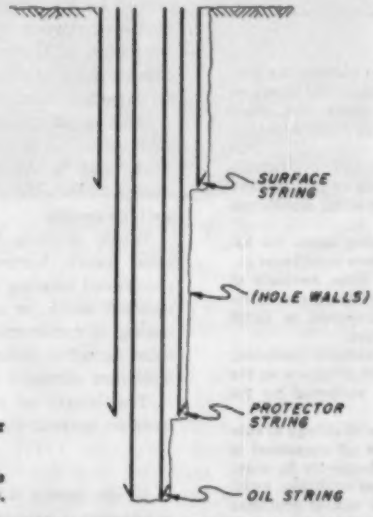


FIG. 2. Program normally used in intermediate drilling conditions and to moderate hole depths.

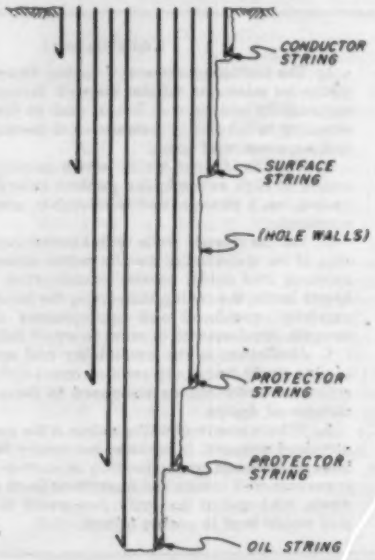


FIG. 3. Typical casing-hole program for deepest drilling and most adverse hole conditions. Conductor string is used in support of marshy or unconsolidated surface soils.

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admitting pressure to the upper formations. This enhances the danger of blow-around and cratering of the wellhead assembly.

Since the protector string has been drilled through, it has sustained some amount of punishment imposed by the rotating drill pipe and is therefore weakened, making it even less suitable in strength. Additionally, the cementing technique used on liners is not as satisfactory as on full strings.

Liner strings are used in practice and with success where hole conditions and liner limitations are mutually compatible. Therefore, they should not be arbitrarily rejected but, if used, done so with care.

Operational Forces

Considering all types of casing strings, the primary-acting operational forces involved are collapse, burst, and tension.

Collapse

Collapse forces are those acting external to the casing which tend to flatten the casing and may even rupture the pipe. These forces may arise from pressures emanating from the formation, that is, either gas or liquids; high columns of fluid standing back of the pipe; by pump pressure applied externally to the pipe; and by the action of salt sections pinching the pipe.

The effects of casing failure include the following:

(a) Withdrawal of tools already in place through the collapsed section becomes problematical.

(b) Running of tools through the collapsed section may be precluded.

(c) Collapse forces of great magnitude can rupture pipe.

(d) Csg. rollers restore near original geometry but yielded pipe provides reduced strength.

(e) If pipe ruptures, internal and external fluid columns are usually unbalanced, and a U-tube flow system can be established. Hydraulic erosion then enlarges rupture. This increases the complexity of corrective operational procedure and enhances the possibility of subsequent trouble.

Burst

Burst refers to any internal force that tends to rupture the pipe. These forces may arise from bottomhole pressure confined internally by the pipe; high internal fluid columns; pump pressure used to fracture, acidize, etc.

Effects of burst are that the rupture allows communication of internal pressure and/or fluid, with initial direction of flow from the inside to the outside of casing. Outer string and the section of hole between casing seats will be subjected to pressure. If their pressure-confining capacity is exceeded, then subsequent trouble is assured.

Tension

This refers to the pull imposed on pipe due to gravity and other causes. Weight of the casing on long strings becomes substantial and must be adequately suspended.

• Shock loading caused by imprudent running procedure adds to tensile stress, i.e. sudden stops and jerks while setting and raising the string in the rotary slips. Shock loading varies with the rate of the change in speed and the involved weight.

• A drop in average casing temperature causes the steel to attempt to contract or shorten. Result is increased tensile stresses.

• An increase in average internal pressure causes the pipe to expand slightly in diameter, with an increase in tensile loading.

• Buoyancy of the casing string caused by immersion of the string in drilling fluid reduces the tensile load.

• Hole friction detracts from tensile load running in the hole and adds to the tensile load if casing is moved upward, such as is encountered in some cementing operations.

• Float equipment of several types is available that imposes various degrees of fill-up in the running operation, which alters the tensile stresses imposed.

From the above, it is apparent that many factors become interacting in determining the amount of pull imposed on top joint of a casing string.

Strength Characteristic of Casing

Collapse resistance. The factors that regulate the resistance of a tube to collapse follow:

1. Where all other factors remain unchanged, increased wall thickness augments resistance to collapse forces. Increased wall thickness is provided by the greater weights of casing.

2. Where all other factors remain unchanged, increased yield strength of the steel material augments resistance to collapse forces. API designation of minimum yield strengths is given by F-25, H-40, J-55, N-80; the alphabetical letter is used for nomenclature and the number refers to the yield strength in thousands of psi.

A given tube located some distance up the hole is subjected to collapsing forces. Simultaneously, it is suspending the weight of lower pipe. The effect of tensile loads acts effectively to reduce the tube's resistance to collapsing forces. Thus, biaxial loading must be taken into account in casing string design. To amplify, consider 5½, J-55, 15.5 lb casing: free of biaxial loading, it is capable of resisting 3860 psi in collapse. Suspending a hanging load of 80,000 lb, it can resist only 3200 psi, or only about 83 per cent of its original capacity.

Burst resistance. The factors that regulate the resistance of a tube to burst rupture follow:

1. Where all other factors remain unchanged, increase of wall thickness augments resistance to burst forces.

2. Similarily, increase of the minimum yield strength augments resistance to burst forces.

Biaxial loading is not considered in burst since hanging loads that do not exceed tensile yield, only slightly improve the tube's resistance to burst.

Tension Strength. There are three locations in a tube that should be examined for strength values in performing casing string design.

1. The strength available in the main body of the tube, which is the product of the wall area in square inches and the longitudinal minimum yield strength in psi.

2. The strength available in the principal threaded portion of the coupling as is given in API specifications for API casing and by the manufacturer for non-API casing. Normally, this is expressed in terms of thousands of pounds pull capacity for minimum ultimate coupling pull-out. This means the least pull that could part the coupling junction by thread separation.

3. The third location which merits examination is at the gage point, referred to as the last fully engaged thread. The wall area remaining under the valley of this last perfect thread, multiplied by the minimum longitudinal yield, corrected for notch stress riser effects, gives the available strength at this point in terms of pounds of yield strength.

Safe procedure is to investigate all three locations for insurance in design procedure. Where these three values are

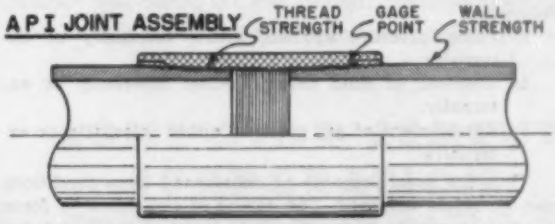

FIG. 4. API casing joint assembly. Shown are points that should be checked to assure adequate strength in suspending the casing string.

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not equal, permissible tension loads are dictated by the least strength.

Force Distribution in Casing Strings

- Maximum tensile stress occurs at the top of the string because string weight is accumulative.
- Maximum collapse forces occur at the bottom of the string because external fluid column pressure is accumulative.
- Maximum burst forces occur at bottom of string because:
  1. Internal fluid column pressure is greatest at bottom because fluid weight is accumulative.
  2. Pump pressure applied internally at surface on top of fluid column produces greatest force at bottom.
  3. Gas pressure coming from bottomhole exists throughout the string but is greater at the bottom than at the top by an amount representative of the weight of the gas column.

Consideration of the above reasonably leads to the conclusion that pipe at the top of the string must provide superior tensile strength and that pipe at the bottom of the string must provide superior collapse strength. When superior strength has been provided at the top and bottom for these reasons, then in the majority of cases the following provisions have also been accomplished in an automatic manner: (1) Usually, adequate burst strength has been provided at the bottom and top of the string. (2) adequate tensile strength has been provided at the bottom of the string. (3) adequate collapse strength has been provided at the top of the string by virtue of tensile requirements.

This then leaves only the central portion of the string, the strength of which may be governed by burst forces. Thus, in a deep hole the string would be composed of three general portions: tensile portion in upper region, burst portion in central region, and collapse portion at lower region.

String Design Criteria

Because of the existing need for specialized performance with respect to depth, the string is divided into functional sections, each section comprised of a kind of casing that can perform the needed function as the least outlay of money and steel tonnage.

When the casing string is run, every attempt is made to reach the casing seat maintaining the mud level at surface. If this is achieved, the internal and external mud columns exert collapse and burst forces that are equivalent. Casing is relatively free of burst and collapse stress for the period of time that these forces are in balance. Great probability exists that conditions will change. For example, if the outer column is thiefed-off to the formation, then mud height is diminished, pressure is lessened, and, if no change occurs in the internal column, then the casing will be subjected to a differential of forces which, in this case, is bursting force. If the external column level lowers to near the casing seat, then the entire weight of the mud column is effective in its attempt to burst the casing. Should the conditions be reversed, then the casing would be subjected to collapse forces of comparable magnitude.

Well conditions seldom exist for any great time interval in exact balance because of various reasons, a few of which follow:

1. Pump pressure applied, either internally or externally.
2. Thief-off of fluid column either internally or externally.
3. Entrainment of gas pressure either internally or externally.

Thus the usual presence of unbalanced force conditions can be safely assumed. The extent of unbalance in force conditions cannot be predicted because of too many unknowns. Unbalance can exist to a maximum, even though its frequency of occurrence is in the minority.

In order to obtain complete insurance against failure in burst or collapse, the assumption must be made that full pressure differentials will be encountered. Therefore, strength requirements in collapse and burst resistance are dictated by mud column weights.

Design Requirements

To design a string, information that must be at hand includes casing size, setting depth, mud weight, and other data.

Design or safety factors are used which, simply stated, refer to the per cent of strength to be used in excess of the calculated expected load in collapse, burst and tension. Because of many unknowns, the exact load that will actually occur cannot be calculated; however, fair approximations of the maximum load that could occur can be made. In general practice, the maximum load is presumed.

In the past, common thinking held that it was preferable to exchange steel cost for high insurance against failure. Of recent years, a revised outlook has gained some adherence that on a sufficiently large drilling program a small incidence of failure could be economically sustained by substantial steel savings. What this reduces to is a discussion on the values that should be selected for design factors. This is a subject on which there is very little agreement of opinion. A survey was made of 21 West Texas operators giving the following results:

For Tension,	For Burst,
11 Operators used 1.80	2 Operators used 1.00
2 Operators used 1.75	16 Operators used 1.100
2 Operators used 1.70	1 Operator used 1.33
6 Operators used 1.60	2 Operators used Other

For Collapse,

1 Operator used 1.170
17 Operators used 1.125
3 Operators used 1.000

Additional design data required is a decision on the extent of differential pressure to be assumed.

Simple Illustrative String Design

The following is a simple example of string design where the following data are assumed for illustrative purposes.

11.5 lb/gallon mud — Maximum Mud Weight at Setting Time

6500 ft — Setting Depth

1.125 — Safety Factor in Collapse

1.80 — Safety Factor in Tension, Minimum Ultimate Coupling Pullout

1.40 — Safety Factor in Tension — Yield at Gage Point

1.00 — Safety Factor in Burst

5½ in. OD — API Casing

Maximum Differential Assumed in Burst and Collapse

Collapse Force — Section A at Bottom. Start at bottom or total depth. Pressure of a 1-ft column equals 0.052 times 11.5 lb, hence the gradient of the column is 0.598 lb. The 6500-ft column would exert a pressure at 3887 psi. Since the pipe's resistance must be 1.125 times greater, 4373 psi strength pipe must be used. From the handbook 17 lb J-55 will qualify, having a collapse resistance of 4500 psi. This gives an actual safety factor of 1.156, which is satisfactory.

Burst Force — Section A. Resistance to burst for 17 lb J-55 is 5320 psi. The maximum differential is 3887 psi, hence actual safety factor is 1.370. This is satisfactory, but greater than necessary.

Collapse for Section B. The collapsing force is greater at the bottom, and less at shallower depths. Hence at some upper depth, having a lesser collapsing force a lighter pipe should be satisfactory. The next lightest pipe is 15.5 lb J-55 with 3860 psi collapse resistance. How deep can this pipe extend in 11.5 lb/bal mud, and suspended Section A in

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biaxial loading? The 3860 psi divided by 1.125 to make allowance for the desired safety factor leaves 3430 psi net collapse resistance. To convert this to setting depth in feet, divided by the gradient giving a trial setting depth of 5700 ft to nearest hundred, which would make Section A 800 ft or a weight of 13,600 lb. Biaxial curves show that 15½ lb J-55 will offer 3800 psi when suspending 13,600 lb. The collapse force at 5700 ft depth is 3410 psi (5700 x 0.598). The strength of 3775 psi divided by 3410 gives a safety factor of about 1.105, which is less than the 1.125 desired. Next, approximate a revised setting depth by trial and error. Arbitrarily selecting some shallower setting depth, say 5500 ft, the following data are tabulated: 1000 ft — Section A (6500-5500 ft); 17,000 lb-weight of Section A (1000 ft x 17 lb); 3725 psi — resistance to collapse, corrected for biaxial tension load (from curves); 3290 psi—collapse force at 5500 ft; 1.13 safety factor, which is satisfactory.

Burst for Section B. The burst resistance of 15.5 lb J-55 is 4810 psi, divided by 3887 psi gives 1.24, which is satisfactory.

Tension for Section A. Section A weights only 17,000 lb, its coupling strength is 234,000 lb; hence the associated safety factor is quite large and may be dismissed.

Collapse of Section C. For economy a lighter tube is again used; this would be 14 lb J-55. Its 3170 psi published value of collapse resistance, reduced by 1.125 safety factor yields 2820 psi, which converted to feet by dividing by 0.598 gives 4700 ft indicated setting depth. Realizing that biaxial loading will further reduce this, an arbitrary trial is made of 4300 ft, with the following tabulation: 1200 ft — Section B (5500-4300); 18,600 lb-weight Section B (15½ x 1200 ft); 17,000 lb-weight Section A; 35,600 lb — total weight suspended at base Section C; 2900 psi — corrected resistance to collapse, 14 lb J-55; 2570 psi — collapse load at 4300 (4300 x .598); 1.125 — safety factor in collapse, which is satisfactory.

Burst of Section C. 14 lb J-55 has a resistance in burst of 4270 psi, which divided by 3887 psi yields a safety factor of 1.10, which is satisfactory.

Tension of Section B. The total load supported at top of Section B by 15.5 lb J-55 is 35,600 lb with a coupling strength of 247,000 lb giving a safety factor quite large.

The next lighter pipe 14 lb H-40 is not practical because of its resistance to burst being only 3110 psi.

Tension of Section C. To determine, by direct method, if 14 lb J-55 will extend to surface, divide coupling strength of 186,000 lb by 1.80, giving 103,000 lb; deduct 35,600 lb weight of Section A and B, leaving 67,400 lb of net strength to be exploited. Thus 67,400 lb will support 4800 ft. Since only 4300 ft is needed to surface, it is satisfactory. Total string weight is 95,800 lb applied against 186,000 lb, giving an actual safety factor of 1.94, which is satisfactory.

The area under the last perfect thread is 2.814 sq in.; yield is 55,000 psi minimum. Applying a 90 per cent correction for notch effects as a stress-riser, the total yield strength is 139,200 lb. This gives a 1.45 safety factor against 95,800 lb, which exceeds the desired value of 1.40.

Design Advantages. A string of only one section, of a given weight and grade, which would give adequate strength would be 17 lb J-55. Compared to it, the designed string is $1793 cheaper, based on current prices, mill prices, freight from Pittsburgh, Pennsylvania, locality to Houston, Texas, and laid down. The designed string further gives an economy of 7.3 tons in steel savings, which in times of steel scarcity is especially significant for several reasons: (1) In large drilling programs, steel savings translate into addi-

ILLUSTRATIVE EXAMPLE

CASING DESIGN RECOMMENDATION- AREA _____ FIELD _____ LEASE _____ KELL NO. _____

CSNG. SIZE 5-1/2 SETTING DEPTH 6,500 FT. with ~~mud~~ estimated Formation Pressure of 3300 PSI DATE _____

CONDITIONS				CASING WEIGHT Buoyancy Disregarded		SAFETY FACTORS BASED ON 11.5 - lbs/gal. MUD			
FLUID	PRESSURES AT VARIOUS DEPTHS					COLLAPSE	TENSION		BURST
	____ FT.	____ FT.	6,500 FT.	Wt. in lbs. of each section of casing.	Total wt. in lbs. hanging under the top cplng. of each section.	Divide published value minimum collapse (corrected for reduction caused by hanging load (col.2) by the mud pressure at bottom of each section (@). No fluid assumed inside casing.	CPLNG. PULLOUT: Divide published value minimum ultimate cplng. pullout by total wt. of all casg. hanging under top cplng. (col2)	YIELD PULLOUT: Multiply area under root of last thread by 90% of minimum yld. divided by total wt. all pipe hanging under top cplng (col.2)	Divide published value for burst by actual formation pressure. If formation pressure is unknown use mud pressure for TD. No fluid or cement assumed back of casing.
EXAMPLE:									
Formation Press. estmtd.	____ PSI	____ PSI	3,300 PSI						
*HOLE FULL 11.5 MUD @	____ PSI @	____ PSI	3,880 PSI						
*HOLE FULL SALT WTR.	____ PSI	____ PSI	3,250 PSI						
*HOLE FULL FRESH WTR.	____ PSI	____ PSI	2,820 PSI						
*Above pressures obtained by multiplying depth by gradient. Gradient obtained by multiplying the fluid wt. lbs. per gal. by the constant 0.052.						PREFERRED MINIMUM SAFETY FACTORS			
						1.125	1.800	1.400	1.000
				COL. 1	COL. 2	COL. 3	COL. 4	COL. 5	COL. 6
0 - 4300 = 4300'	J-55	14#	STC API	60,200	95,800	1.125	1.94	1.45	1.10
4300 - 5500 = 1200'	J-55	15-1/2#	STC API	18,600	35,600	1.13	ok	ok	1.24
5500 - 6500 = 1000'	J-55	17#	STC API	17,000	17,000	1.156	ok	ok	1.35

FIG. 5. Form used in designing casing strings. Shown is the solution and use of this form in the example design given in this article.

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tional wildcat wells that may be cased, which otherwise would not be drilled. (2) or, steel savings, in large drilling programs can be translated into additional field producers drilled annually with increases in yearly production.

This case for designed strings is accepted industry-wise. However, the shortage of casing stocks often interferes with achieving maximum economy.

The design of strings for very deep wells using chiefly non-API high-strength casing is basically the same as for API casing. However, some modifications of technique are appropriate. The cost of API casing, comparing like tubes, is often equal in price. API specifications assure that the strengths will be equivalent.

Non-API casing is generally of high strength in excess of 80,000 psi minimum yield. Not being governed by API specifications, there are frequently substantial differences in strength for collapse, burst, tension, among tubes having the same OD and wall thickness. Comparisons of costs exhibit considerable variation.

Previous work[2] shows that these costs can be compared on a unit cost/strength basis to aid in the selection of the most economic casing to be used under conditions of burst, collapse, and tension. Representative data compiled on five makes of non-API 7-in. OD 26 lb/ft casing indicate variations in costs of $37.80 to $56.70 per 1000 psi of collapse; $.459 to $.585 per 1000 lb in tension; and $33.20 to $41.60 per 1000 psi of burst resistance.

Due to this wide variation, it follows that substantial savings can be made through the selection of that make of casing which offers the lowest cost per unit strength for each condition.

It has been found that only rarely would any one casing excel pricewise in more than one strength category. Also it has been found that by using the kinds of casing which demonstrate the lowest cost/strength, savings up to 20 per cent can be made over the use of any one kind of casing.

Design Methods

Various methods of designing strings are used throughout the industry.

Design Charts. Previously prepared charts are used extensively. Their advantages are speed, simplicity, and suitability for non-technical personnel permitting string selections to be made by clerical employees. Their disadvantage is that if one type of pipe called for by the chart is not available, then that chart cannot be used.

Individual Calculation. As used in the illustrative example, individual calculation has the advantage of serving with any and all kinds of casing that might require investigation for suitability in string use. Its disadvantage is that trained personnel are needed for its use. It is the only method that can give a precise, tailored treatment for non-uniform and specialized well conditions.

Clearance Considerations

Necessary clearance requirements can present a difficult and expensive problem on deep wells where adverse drilling conditions exist. To permit running passage, it is always necessary that the pipe string be smaller than the respective hole; that the succeeding bit run through this string must be smaller than this pipe, etc., with the result that hole diameter is lost amazingly fast. As an example of most severe conditions: Starting with a 20-in. hole, 16-in. casing could be set, drilling through this with a 14¾-in. bit; in this 14¾-in. hole 10¾-in. casing could be set; then drilling through with 9⅝-in. bit; setting 7⅝-in. flush-joint casing and drilling through with 6½-in. bit with use of 5-in. flush-joint casing having an internal diameter of approximately 4¼ in. An initial diameter of 20 in. is shrunk to about 4¼ in., caused by the ever-present need of running clearances.

Objective is to reach desired total depth before hole diameter vanishes, and the latter can win the race where severely adverse hole conditions necessitating strings occur repeatedly and where the objective total depth is quite advanced. One means to converse hole diameter is the use of flush-joint casing connections to reduce the overall pipe diameter. This serves for limited lengths only because of the reduced tensile strength and has the disadvantage that flush-joint connections are subject to breakage in bending such as at dog-legs and particularly when buckled in cavernous hole conditions.

An additional factor which causes further complexity is the selection of preferred bit types. Where penetration costs are quite high, a specific type of bit may provide substantial economy making its use nearly mandatory. In some cases, it may not be available in a size which is compatible with proposed casing strings. One common recourse in such instances is to adjust the casing string design giving thinner walls at a sacrifice of strengths with regulation of operating precedure in conformance therewith, all to benefit by the gain of substantial penetration economies.

Care and Handling of Casing Above Ground

This subject is nearly as old as casing itself; it has been repeated countless times and the involved reasons are generally known but not always realized since there is still much room left for improvement in the care and handling of tubes throughout industry. The economics behind casing can be typically briefed by the realization that the failure of a $40 joint can void a $40,000 string intended to guard a $400,000 well. These economics merit sincere intent and effective effort on the part of supervisory personnel at the mill, in transit, and at the well.

Some suggested precautions follow:

Handling procedure, beginning at mill — avoid blows, banging, and jars.

Visual inspection of pipe should be made before running in well.

Protection from corrosion while stored on racks.

Protectors in place while handling.

Slip elevators for long strings.

Collar — Pull elevators should give good fit and a uniform bearing surface.

Rotary bowl should be in good condition with all surfaces smooth, true, and not worn.

Threads thoroughly cleaned and inspected; damaged threads should be laid aside unless satisfactorily repaired.

Equip joint with thread protector to roll on rack and pull into derrick.

Lower pipe carefully to walk, snub if necessary.

Apply clean thread compound to pin and box threads.

Stab carefully without damage to threads.

Avoid striking pipe against any object of equipment while pulling into derrick; provide rope hold-back at Vee door.

Rack testing for pressure confinement when justified by conditions.

Stab vertically, with care, protecting threads; make up slowly initially to check cross threading.

Make up to correct and uniform torque, normally three turns beyond hand tight for 7⅝ and larger; or additional makeup if needed.

Wobbling of pipe during makeup, at slow speeds indicates the thread may not be in line with axis of pipe, should be laid down and shopped.

Makeup of the mill-end on the coupling is permissible.

Strings should be picked up and set down carefully to avoid shock loads.

Exercise care to run string in exact relationship as designed; transposing joints from one section to another should be avoided.

Casing at junction of wellhead and surface string should be strong enough to support all down-hole loads.

Avoid pinching casing at wellhead slips by choice of

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Conditions and Operations	Change in Acting Stresses* Tension Loading	Collapse Loading	Burst Loading	Buckling Tendency
1. Drop in average temperature	Increase	—	—	Decrease
2. Rise in average temperature	Decrease	—	—	Increase
3. Rise of internal pressure	Increase	—	Increase	Increase
4. Drop of internal pressure	Decrease	—	Decrease	Decrease
5. Rise of external pressure	Decrease	Increase	—	Decrease
6. Drop of external pressure	Increase	Decrease	—	Increase
7. Replacement of internal fluid by a heavier fluid	Increase	—	Increase	Increase
8. Replacement of internal fluid by a lighter fluid	Decrease	—	Decrease	Decrease
9. Replacement of external fluid by a heavier fluid	Decrease	Increase	—	Decrease
10. Replacement of external fluid by a lighter fluid	Increase	Decrease	—	Increase
11. Swab down	Decrease	—	Decrease	Decrease

*NOTE: Above pressure changes (3-6 inclusive) can arise from brake horsepower, hydrostatic pressure, pump pressure in acidizing, squeeze, fractures, gas injection, water injection, etc.

appropriate wellheads.

Many string failures have occurred in practice, some of which could have been prevented by simple precautionary practices.

Sub-Surface Use of Casing

Suggested precautions follow for the use of casing in the hole.

Use drill pipe protectors on all drill pipe inside casing while drilling ahead. Regular check, and replacements if necessary, should always assure that protector diameter exceeds that of tool joints.

Casing located in a hole section which is cavernous should be surrounded by cement if possible, to prevent buckling and possible pin breakage. This is particularly true of flush-joint casing because of the fragility of the thin wall section. Where cement fillup cannot be obtained, the greater diameter of these caverns may offer some possibility of running conventional couplings.

Welding of casing has been the subject of much controversy, as in the case of installing cementing equipment by field welders. Practice employs widely the field-welding of H-40 and J-55 casing. Success of welding N-80 depends quite largely on the skill of the field welder. Many who are conscious of this risk resort, in some cases, to techniques not requiring welding; or the hire of only competent and skilled field welders. Non-API, high-strength casing with minimum yields greater than 80,000 psi should not be field-welded indiscriminately and without investigation.

The application of internal pressure in casing strings is commonly limited in practice by its rated resistance to burst, or some per cent thereof. Past thinking generally concluded that this was the only behavior factor involved. Investigations of recent years have developed that where certain ambient-force conditions existed, internal pressure of critical values could also cause buckling of the casing string. Where pipe is surrounded by cement, buckling is prevented, or in full-gage holes buckling is reduced to small harmless values. However, in large-diameter cavernous holes of, say, several joint height, the risk of pin breakage is believed to be substantial, and such hole conditions are commonly calipered in the Gulf Coast area. Cases are recalled where tubing setting on a packer (fixed ends as with casing) was subjected to high internal pressure. Subsequently upon pulling, several joints of the tubing were "corkscrewed" permanently in a spiral. This was buckling magnified. Further, three casing strings designed with exceptionally high safety factors are known to have suffered failure by complete parting, all at depths of about 8000 ft. Calculations on force conditions indicated the presence of heavy buckling stress. The average cost for each of these three failures exceeded $100,000.

Casing landing procedure affects down-hole performance of casing and is a subject that has been widely discussed. The function of landing casing in accordance with chosen plan is to minimize stresses and avoid critical stresses that would likely cause string failure. A review of some of the numerous factors that should be considered when promulgrating landing procedure include design factors, rise and drop in average temperature, rise and drop of internal pressure, rise and drop of external pressure, replacement of internal fluid by a heavier and a lighter fluid, replacement of external fluid by a heavier and a lighter fluid, swab down, etc.

It is well to know the effects imposed by the above factors on the various types of stresses acting on casing strings.[5]

The preceeding tabulation shows how the four principal stresses, which bear on casing, are either increased or decreased by actual operations practices and conditions. Obviously, the strengths provided by the casing should always be superior to the imposed stresses and leave a safe margin remaining.

Next of immediate and primary importance is to learn in what way safe margins are altered, by the various landing methods, when casing is subjected to the various acting stresses.

Acting Stress	Magnitude of Safe Margin Where Landing Method Is: Pull-Up	As Cemented	Slack-Off
(A) Longitudinal tensile loading	Least	Intermediate	Greatest
(B) Collapse loading, or transverse compression	Least	Intermediate	Greatest*
(C) Burst loading	Greatest	Intermediate	Least*
(D) Buckling	Greatest	Intermediate	Least
(E) Longitudinal compression force	Greatest	Intermediate	Least

*Change here is small, 5 per cent ± and usually ignored in design calculations.

From the above, it is shown that in the overall picture of all possible acting stresses that the "As Cemented" method of landing casing string gives intermediate values for all possible safe margins, where all possible acting stresses are imposed during the life of the well. For this reason, the "As Cemented" method has great merit, since at landing time it is never known what acting stresses will be existent, nor could their magnitude be approximated even if their identity were known. Thus, it is apparent that the necessity exists to, not only design for unknown loads so the maximum is presumed, but to also land in such a manner that the possible future appearance of some unknown stresses existing in unknown magnitudes will, in finality, inflict only the minimum reduction on safe margins. Explanations in greater detail, precluded here because of space limitations, are available in API reports.[6]

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4. Bouman, C. A. "Buckling of Oil Well Piping," *The Petroleum Engineer*, June, 1956.
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6. *The API Monogram*. Spring-Summer 1955, page 15.

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EXCLUSIVE

With Spring-Loaded Fluid-Operated Valves

CALCULATING A Gas-Lift Installation

William B. (Ben) Adair
Registered Professional Engineer, Bellaire, Texas

A NUMBER of installations and experience in recent years point the way to better engineered gas-lift systems employing the new spring-loaded, fluid-operated type valve. Although some of the factors required for making valve setting calculations may not be known at the time the system is in the planning stage, cumulative experience makes it possible to find the operating range of these variables so that a gas-lift installation can be better designed. But, given normal field data, either a graphical or a mathematical analysis may be made to determine the proper placement of valves to lift the desired volume of fluid. Fluid has been lifted from as deep as 10,400 ft by intermittent flow and in volumes of 2600 bbl daily by continuous flow.

The fluid-operated valve is actuated by a predetermined hydrostatic fluid head in the tubing. When the fluid column in the tubing builds up sufficient pressure at the valve to overcome the valve opening pressure, the valve stem is lifted off its seat. Then, gas from the casing is injected through a normally closed check valve into the tubing, discharging the accumulated head of fluid. Mandrel arrangements for the fluid operated valve seals the valve bellows from the casing pressure, and the pressure exerted by the fluid column in the tubing is the predominant valve-opening force.

When the tubing pressure opposite the valve becomes lower than the valve opening pressure, the valve immediately closes until another predetermined head is built up in the tubing and the cycle is repeated. Subsequent action is automatic and unloading from valve to valve is automatic.

The spring-loaded fluid-operated valve is illustrated in Fig. 1. There is no charge in the bellows, and the spring tension is set as the valve opening pressure. The bellows functions only as a diaphragm, and the spring functions as the total actuating force. Spring tension keeps the valve closed until a desired predetermined head of fluid has entered the tubing. Once a valve opening pressure is set by spring tension, the pressure remains unchanged regardless of hydrostatic pressure or temperature applied to the valve in the well. Hence, the opening pressure of the valve is known regardless of the operating depth, and installations may be designed accordingly. Since the spring is the total actuating force, it may be set with either extremely high or low opening pressure (100 to 3000 psi).

Intermittent Flow

The intermittently produced gas-lift well normally has a producing capacity of less than 500 bbl per day and fluid is produced at intervals in "slugs." In an intermittently produced well fitted with fluid-operated valves, a small choke is installed in the casing inlet to control rate of gas injection into the annulus. The size of choke is adjusted so that the fluid head from the well is lifted with the minimum amount of gas. At the operating valve, gas injection is controlled into the tubing by producing characteristics of the well—therefore, gas is not unnecessarily injected into the tubing when a rate of production declines.

Charts and technical data courtesy of Macco Oil Tool Company.

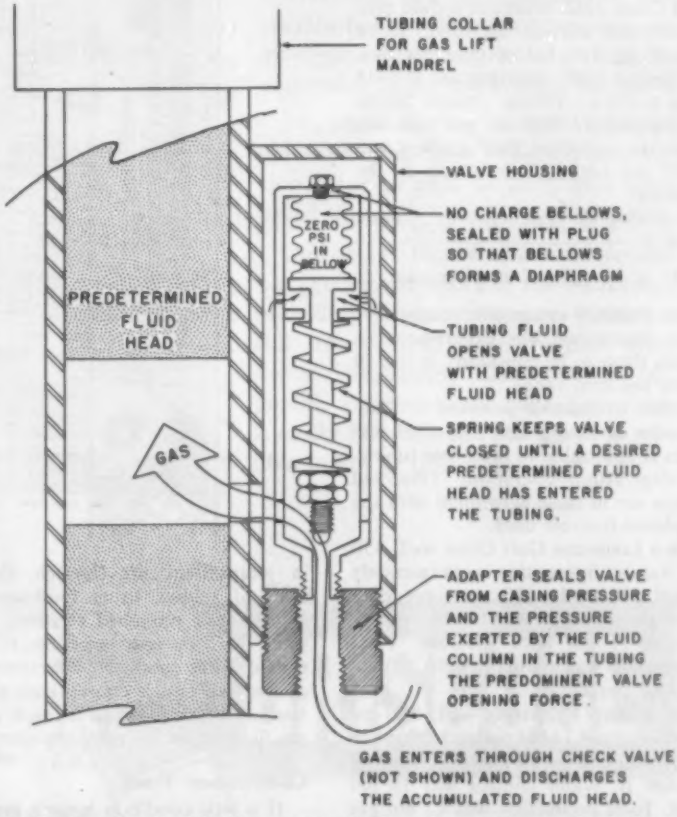

TUBING COLLAR FOR GAS LIFT MANDREL
VALVE HOUSING
NO CHARGE BELLOWS, SEALED WITH PLUG SO THAT BELLOWS FORMS A DIAPHRAGM
ZERO PSI IN BELLOW
PREDETERMINED FLUID HEAD
TUBING FLUID OPENS VALVE WITH PREDETERMINED FLUID HEAD
GAS
SPRING KEEPS VALVE CLOSED UNTIL A DESIRED PREDETERMINED FLUID HEAD HAS ENTERED THE TUBING.
ADAPTER SEALS VALVE FROM CASING PRESSURE AND THE PRESSURE EXERTED BY THE FLUID COLUMN IN THE TUBING THE PREDOMINENT VALVE OPENING FORCE.
GAS ENTERS THROUGH CHECK VALVE (NOT SHOWN) AND DISCHARGES THE ACCUMULATED FLUID HEAD.

FIG. 1. **Spring-loaded fluid-operated lift valve and mandrel.** The valve is actuated by a predetermined hydrostatic fluid head in the tubing. Spring tension holds the valve closed until the head of fluid has entered the tubing.

The intermittently produced gas-lift well has a producing capacity depending on tubing size, available gas pressure, and depth of lift. The predetermined fluid head which opens the fluid-operated valve and is subsequently delivered into the stock tank may be approximated by using the following empirical formula:

$$Q = \frac{E(P_v - P_b) \times C}{G_f}$$

Q = is the fluid produced per cycle, barrels.
E = is the "sweep efficiency."
P_v = is the valve opening pressure, psi.
P_b = is the back pressure at the surface, psi.
G_f = is the gradient of the dead fluid, psi per ft.
C = is the constant for tubing volume, bbl per ft.

The engineer considering gas-lift problems will find factors in the above mentioned formula that are sometimes difficult to evaluate. Results obtained from the method outlined, however, have been found to be in reasonable agreement with observed results in hundreds of actual field tests with fluid-operated valves. For example, using 450 psi fluid-operated valves in a Texas Gulf Coast field, results of a fluid production test showed the valves to be slug lifting 787 bbl of fluid per day, 4.6 bbl per cycle, injecting gas at 3944 ft in a 2½-in. tubing, against 50 psi back pressure. With 92 per cent salt water the estimated fluid gradient was 0.457 psi per ft. Substituting in the formula:

$$4.6 = \frac{E \times (450 - 50) \times .00579}{0.457}$$

$$E = .908 = 90.8 \text{ per cent}$$

No exacting sweep efficiencies have been determined but experience has shown them to be constantly in the 70 to 90 per cent range.

Since hydrostatic pressure is independent of tubing size, the same formula is applicable to macaroni tubing, in slug lifting operations. Observed results are in close agreement with the empirical formula used.

In a Louisiana Gulf Coast well, 550 psi valves intermitted approximately 2 bbl per cycle (90 per cent cut) through 4800 ft of 1½-in. tubing against 75 psi back pressure. Total production was approximately 340 bbl of fluid per day.

In a deep California well, 800 psi valves slugged 14 bbl per cycle, through 3-in. tubing, from an injection depth of 10,400 ft. Water content was 19 per cent. Total production was 42 bbl per day of fluid. From these and many other actual field tests, evidence indicates that the friction factors involved

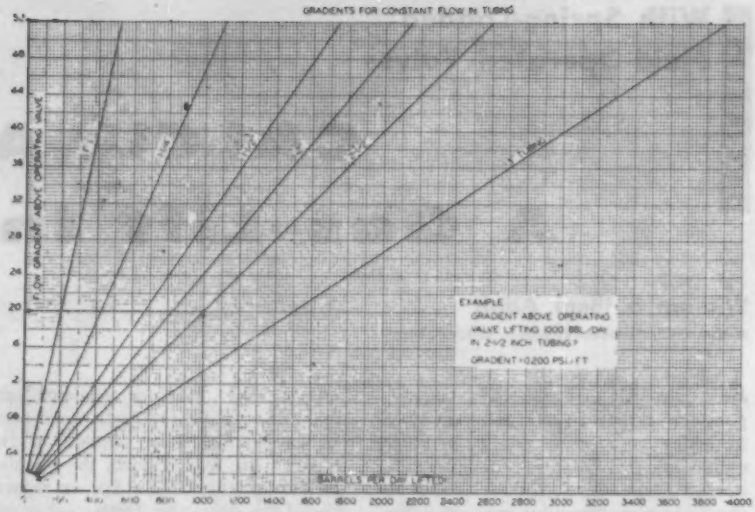

GRADIENTS FOR CONSTANT FLOW IN TUBING
EXAMPLE
GRADIENT ABOVE OPERATING VALVE LIFTING 1000 BBL./DAY IN 2½ INCH TUBING?
GRADIENT = 0.200 PSI./FT.

Chart 1

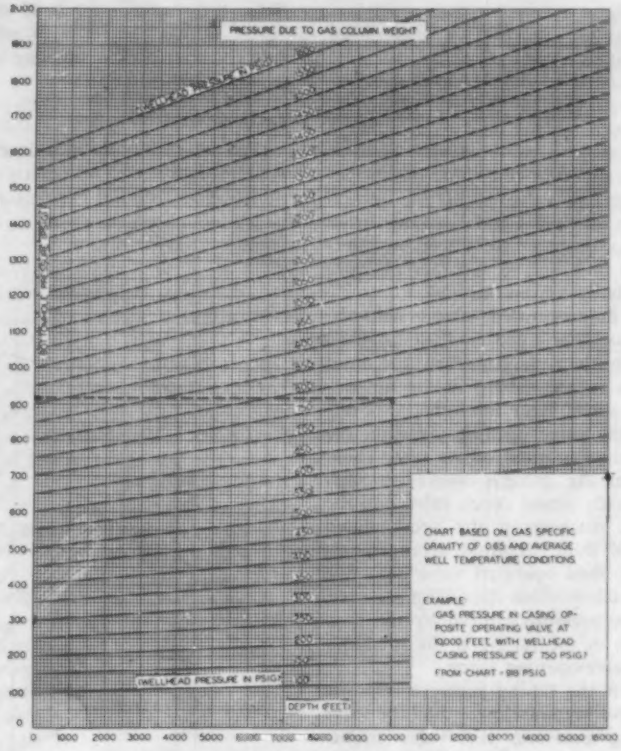
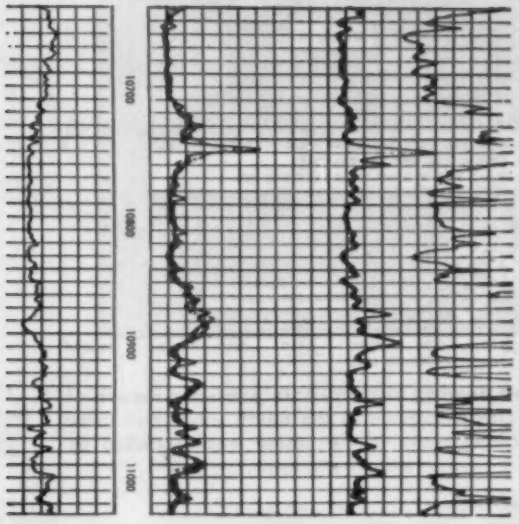

PRESSURE DUE TO GAS COLUMN WEIGHT
CHART BASED ON GAS SPECIFIC GRAVITY OF 0.65 AND AVERAGE WELL TEMPERATURE CONDITIONS
EXAMPLE
GAS PRESSURE IN CASING OPPOSITE OPERATING VALVE AT 10,000 FEET, WITH WELLHEAD CASING PRESSURE OF 750 PSIG?
FROM CHART = 918 PSIG
WELLHEAD PRESSURE IN PSIG
DEPTH IN FEET

Chart 2

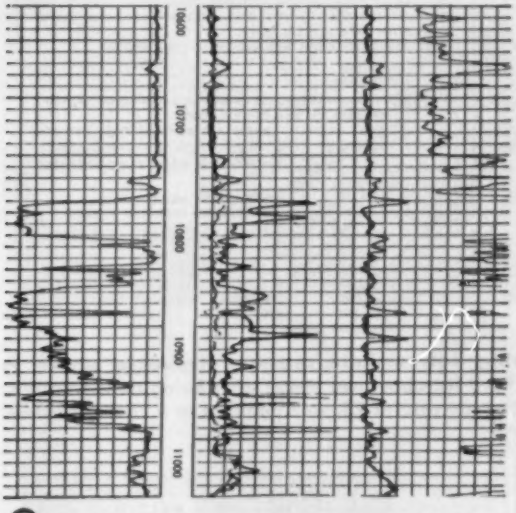
in intermittent lift through various sizes of tubing, using fluid-operated valves, have remained relatively constant. Because gas injection is controlled by the producing characteristics of the well and is coordinated with a *known* volume of fluid at each cycle, gas fluid ratios are normally very low.

Continuous Flow

If a well condition is such that the flowing bottom-hole pressure will feed past the point of injection at a rate sufficient to maintain a pressure opposite the valve greater than the valve opening pressure, delivery of fluid from the flow string is constant. Fluid-operated valves thus achieve one point injection at the maximum depth the available gas can enter the tubing string. It follows that wells may be efficiently lifted from great depths because full available energy is used at the operating valve. Pressure gradient traverses for 2, 2½, and 3-in. tubing sizes have been made in flowing and gas-lift wells to determine "aerated" flow gradients for various rates of production.

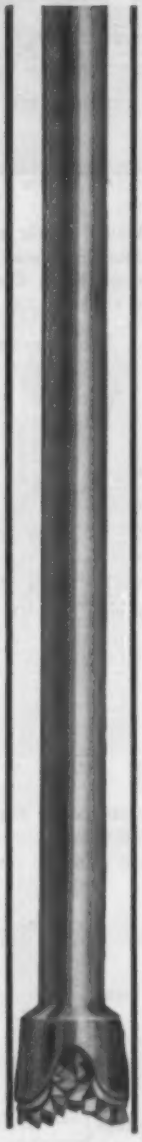


❶ Section of Well No. 1, logged in a lime base, oil emulsion system. Log in this mud offers some interpretation and correlation problems.



❷ Well No. 2, with paralleling strategraphic structure, was drilled with a DRISCOSE low solid emulsion system. Observe the improved spontaneous potential curve on the left. Furthermore, no mechanical or gelation problems.

DRISCOSE*



improves your electric log!

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Field data from these tests have been compiled and resolved to numerous "F factor" graphs for usage in designing gas-lift installations for constant flow valves. Although most of the graphs are in relatively close agreement, wide ranges of actual continuous flow gradients are encountered, due to the many variables involved. The "F factors" are normally used simply as a basic assumption in spacing valves for continuous flow. The assumed gradient may or may not actually occur when the well is being lifted. Higher gradients are encountered in macaroni tubing lift, and the demand for production capacity must be reduced accordingly. Available gas pressure, tubing size, and depth of lift again are the primary considerations. These are some actual observed rates of production for various sizes of tubing and lift conditions:

2½-in. tubing — 2800 bbl of fluid per day, lifting with 700 psi gas.
2-in. tubing — 1700 bbl of fluid per day, lifting with 700 psi gas.
1½-in. tubing — 700 bbl of fluid per day, lifting with 800 psi gas.
1¼-in. tubing — 435 bbl of fluid per day, lifting with 600 psi gas.
1-in. tubing — 300 bbl of fluid per day, lifting with 500 psi gas.

The above table of actual observed rates of production, gas-lifted by continuous flow with fluid-operated valves, was made to give an indication of the ranges of production that may be expected for the tubing sizes shown. These figures represent only observed production rates under certain conditions and should not be interpreted as being maximum production possible from these tubing sizes. The maximum rates that may be lifted depend primarily upon depth of lift, available gas pressure, and the friction factors involved in flow through tubing.

By combining field production data with known gas-lift pressure and fluid-operated valve settings, the curves for evaluating the "F factor" inside macaroni tubing strings were derived (Chart 1). These curves may be used to assist the gas-lift engineer in placement of valves for continuous lift.

Valve spacing. In typical fluid-operated valve installations, spacing usually follows the simple rule of "foot per pound." For example, available gas of 500 psi calls for 500-ft spacing between valves. On wells with very high productivity indices, placement of valves is of prime importance and must be considered. Given normal field data, either a graphical analysis or a mathematical analysis may be made to determine the proper placement of valves to lift desired amount of fluid.

Since fluid-operated valve installations may be designed to utilize full available operating gas pressure at the valve, calculations are usually less involved.

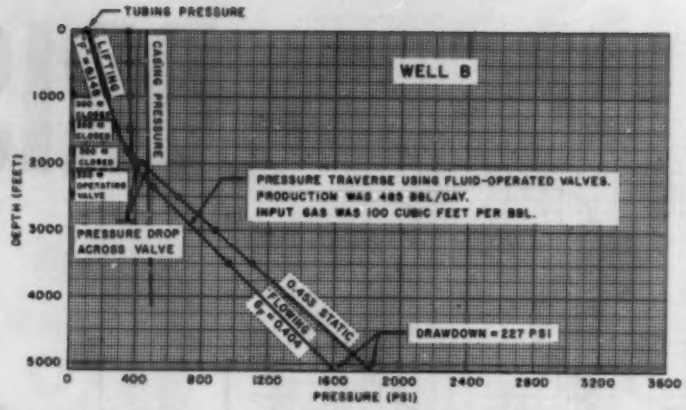

FIG. 2. **Actual static and flowing bottom-hole pressure record** of a continuous-lifted well. Gas is injected at the fourth valve, and there is no tubing choke. Gas inlet choke in the casing was controlled by adjustable choke.

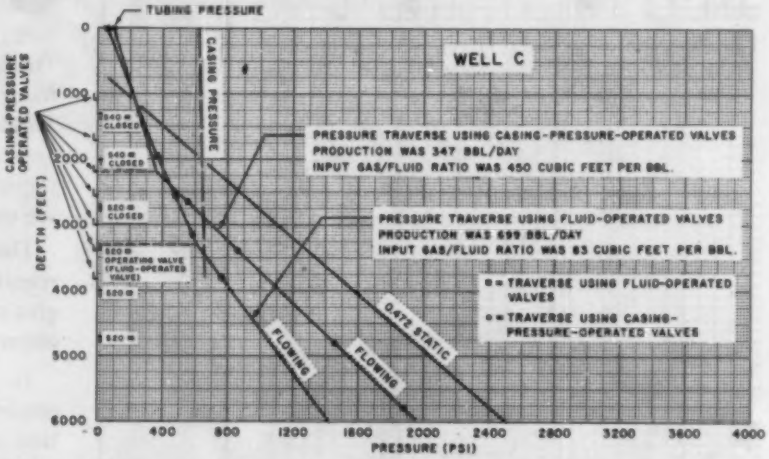

FIG. 3. **Static and flowing bottom-hole pressure traverse** plotted vs depth. Well C intermitted itself for about two weeks after being turned on production, but when oil percentage rose to 25, well adjusted to a continuous-flow operation.

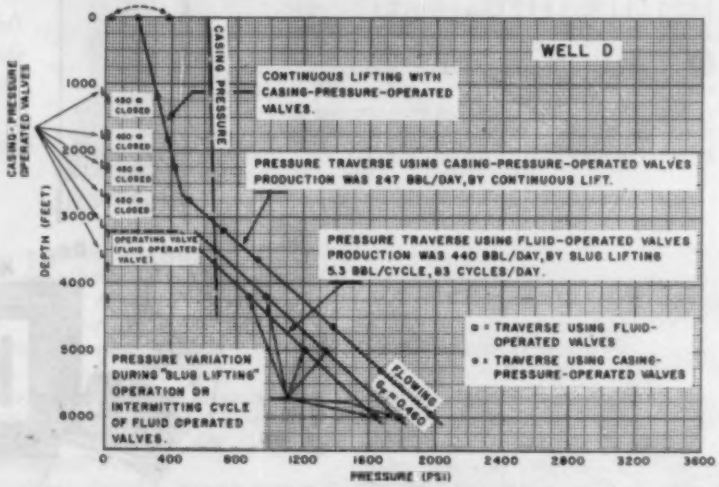
WELL D
CASING PRESSURE
CONTINUOUS LIFTING WITH CASING-PRESSURE-OPERATED VALVES.
PRESSURE TRAVERSE USING CASING-PRESSURE-OPERATED VALVES
PRODUCTION WAS 247 BBL/DAY, BY CONTINUOUS LIFT.
PRESSURE TRAVERSE USING FLUID-OPERATED VALVES
PRODUCTION WAS 440 BBL/DAY, BY SLUG LIFTING
5.3 BBL/CYCLE, 83 CYCLES/DAY.
= TRAVERSE USING FLUID-OPERATED VALVES
= TRAVERSE USING CASING-PRESSURE-OPERATED VALVES
PRESSURE VARIATION DURING "SLUG LIFTING" OPERATION OR INTERMITTING CYCLE OF FLUID OPERATED VALVES.
FLOWING
Gf = 0.460
CASING-PRESSURE OPERATED VALVES
DEPTH (FEET)
PRESSURE (PSI)

FIG. 4. **Well D's** actual flowing bottom-hole pressure traverse, showing pressures that occurred during production with both casing pressure and fluid-operated valves.

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By: R. M. Pyles
R. M. Pyles, Superintendent

RMP/d

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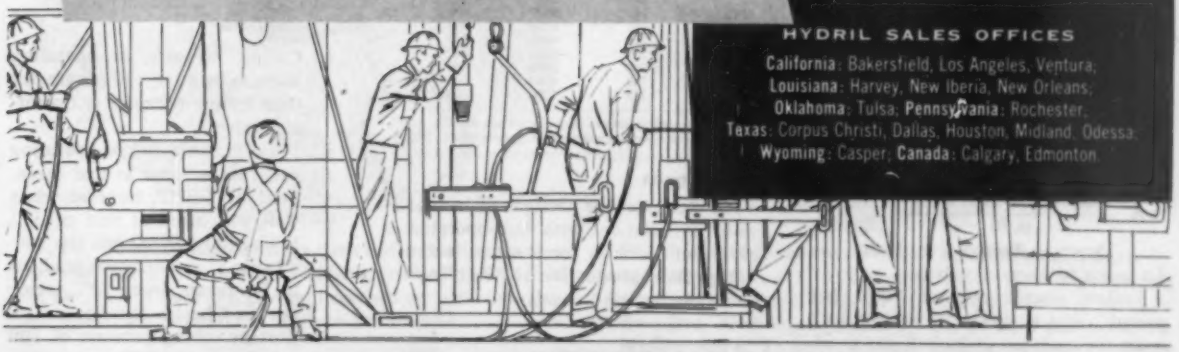

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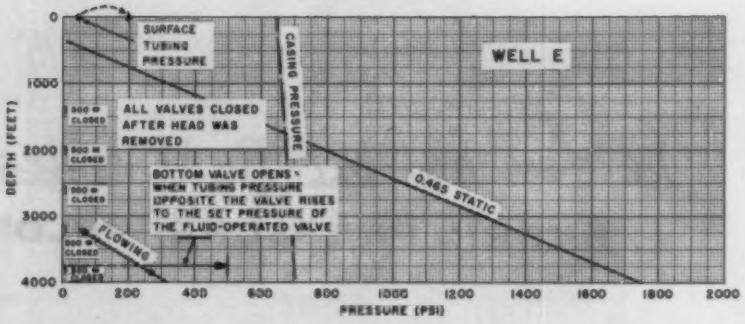
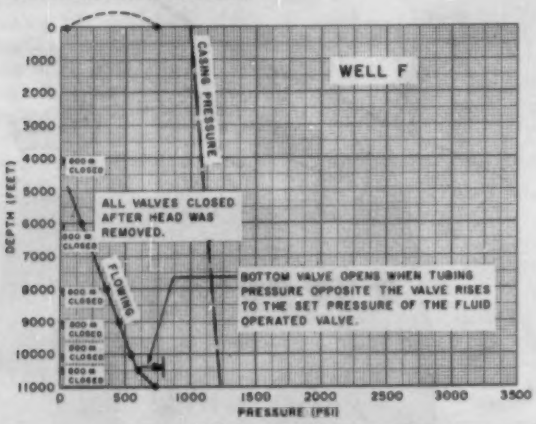
FIG. 5. **Record of Well E's** actual flowing bottom-hole pressure. Well E is intermittently-lifted. It has just made a head of fluid and all valves are closed. When fluid builds up enough pressure opposite bottom valve, gas will be admitted to tubing and will slug-lift the head to the surface.

FIG. 6. **Graph** of an actual flowing bottom-hole pressure traverse of an intermittently-lifted well. Casing is equipped with an adjustable choke for gas inlet; tubing has a 24/64-in. positive choke in the flow line.


WELL E
SURFACE TUBING PRESSURE
CASING PRESSURE
ALL VALVES CLOSED AFTER HEAD WAS REMOVED
BOTTOM VALVE OPENS WHEN TUBING PRESSURE OPPOSITE THE VALVE RISES TO THE SET PRESSURE OF THE FLUID-OPERATED VALVE
0.465 STATIC
FLOWING
DEPTH (FEET)
PRESSURE (PSI)


WELL F
CASING PRESSURE
ALL VALVES CLOSED AFTER HEAD WAS REMOVED.
BOTTOM VALVE OPENS WHEN TUBING PRESSURE OPPOSITE THE VALVE RISES TO THE SET PRESSURE OF THE FLUID OPERATED VALVE.
FLOWING
DEPTH (FEET)
PRESSURE (PSI)

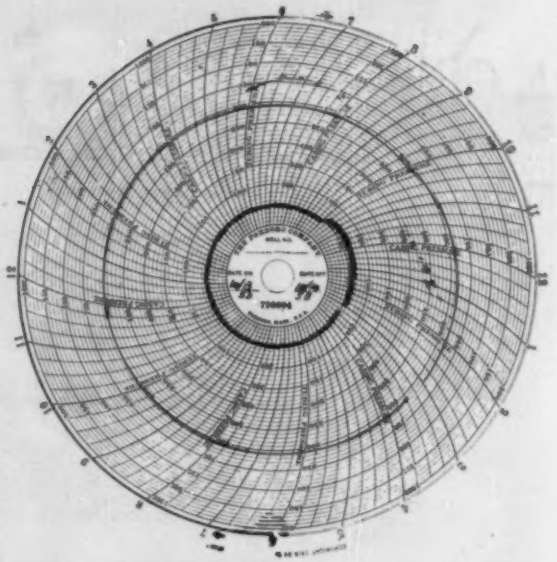


FIG. 7. **Continuous-flow type well** pressure recording chart. Well is using fluid-operated gas lift valves. Production on test was 1034 bbl per day with injection gas-fluid ratio of 49 cu ft per bbl. Casing inlet choke was a 6/64-in. positive choke.

Valve spacing in continuous-flow wells is essentially the same as in the intermittent-type wells. In large volume wells (700 bbl per day or more), however, the bottom valves are normally spaced closer together to give the operator greater flexibility in changing the operating valve. The operating valve may be changed by adjusting the inlet-choke size until the fluid gradient is lowered or raised as desired, thus changing the point in the tubing where the available gas will continuous-flow the desired fluid production.

Well Data: (Typical Slug-Lifted Well)

Total depth of well, feet	7500
Static bottom-hole pressure, psi	3750
Productivity Index	0.1
Total fluid desired, bbl per day	200
Tubing size, inches	2
Casing size, inches—OD	5.5
Gradient of well fluid, psi per foot	0.465
Available kickoff gas pressure, psi	750
Available operating gas pressure, psi	750
Normal separator pressure tubing and annulus loaded with salt water.	

To space first valve from surface:

$$A.\ \frac{\text{Kickoff Gas Pressure}}{0.50} =$$

Depth to First Valve, Feet

To space balance of valves:

Follow simple rule of "foot per pound"; that is, space valves one foot apart for each psi of kickoff gas available.

$$B.\ \frac{\text{Kickoff Gas Pressure}}{1.0} =$$

Spacing Between *All* Valves, Feet

Example: (Using Well Data Above)

To space first valve from surface: (Set at 600 psi ***)

$$\frac{750}{0.50} = 1500 \text{ ft}$$

To space balance of valves: (All set at 600 psi)

$$\frac{750}{1.0} = 750 \text{ ft apart}$$

Valve No.	Spacing Ft	Depth Ft	Valve Pressure psi
1	1500	1500	600
2	750	2250	600
3	750	3000	600
4	750	3750	600
5	750	4500	600
6	750	5250	600
7	750	6000	600
8	750	6750	600
9	750	7500	600

*** Fluid-operated valves are normally set to open 150 psi below available operating gas pressure for intermittent lift.

Field Cases

To illustrate the design of actual gas-lift installations with fluid-operated valves, let's look at some actual wells.

High fluid production in Well "A," the following was known:

Total depth of well, feet	5100
Static bottom-hole pressure at 5100, psi	1825
Productivity Index, bbl per day per psi	16.7
Total fluid desired, bbl per day	Max. lift capacity
Tubing size, inches nominal	2½
Casing size, inches—OD	7
Gradient of oil-water mixture below operating valve, psi per ft	0.441
Available kickoff gas pressure, psi	475
Available operating gas pressure, psi	450
Tubing and annulus loaded with salt water	

The well was originally equipped with four specific-gravity-operated type valves to 2313 ft. The operating valve was at 1635 ft, lifting 552 bbl per day gross fluid with an input gas-fluid ratio of 130 cu ft per bbl. Surface tubing pressure was 98 psi. Gradient of well fluid below the operating valve was 0.441 psi per ft.

Calculations for spacing the fluid-operated valves were as follows:

A. Assumptions

1. Casing pressure at operating valve to be 80 to 120 psi greater than tubing pressure at operating valve.
2. Fluid gradient below operating valve to be same as that measured by FBHP traverse when well was lifted at rate of 552 bbl per day. Symbol is G_f.
3. "Lifting" or aerated gradient to be taken from "F" factor curves, Chart 1. Symbol is F.
4. Surface tubing pressure of 100 psi. Symbol is STP.

5. Symbol for depth to operating valve is D_{ov}.
6. Symbol for total depth is TD.

B. Calculations by "Cut and Try" method:

1. "Try" 750 bbl per day
2. BHP Drawdown = Bbl per day ÷ PI
   = 750 bbl per day ÷ 16.7 bbl per day
   = 45 psi
3. Flowing BHP = Static BHP — Drawdown
   = 1825 psi — 45 psi
   FBHP = 1780 psi
4. From Chart 1, "F" = 0.15 psi per ft
5. $STP + F(D_{ov}) + G_f (TD - D_{ov}) = FBHP$
   $100 + .15\ (D_{ov}) + 0.141\ (5100 - D_{ov}) = 1780$
   $D_{ov} = 1950$ ft
6. Tubing pressure at operating valve =
   $STP + F(D_{ov}) =$
   $100 + .15\ (1950) =$
   Tbg press at 1950 ft = 392 psi
7. Casing pressure at operating valve = See Chart 2

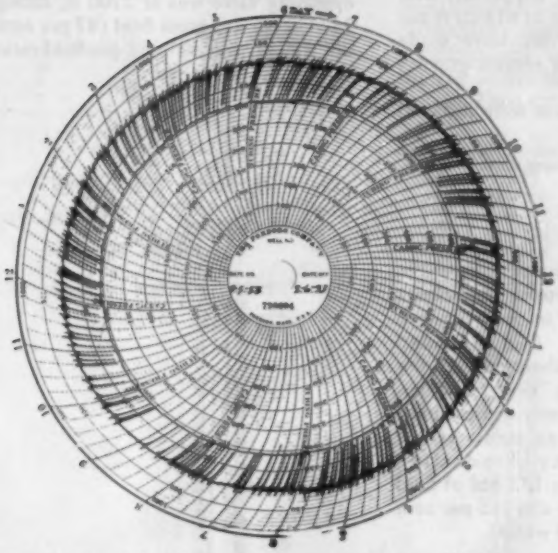


FIG. 8. **Combination flowing and gas-lifted, or "twilight" well** pressure chart. Well must be periodically stimulated when tubing pressure drops and well begins to load up.

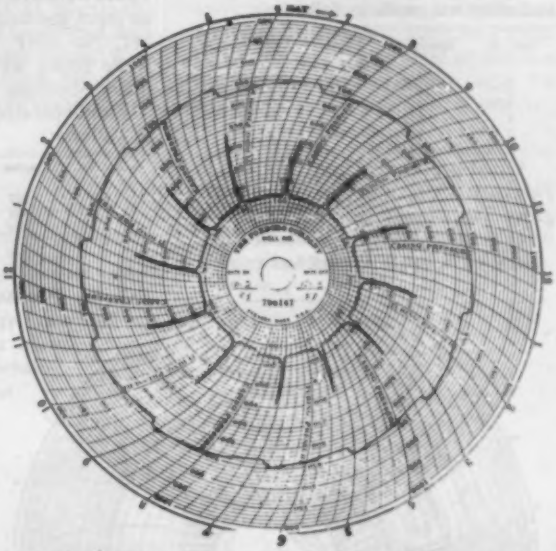


FIG. 9. Intermittent-type well pressure recording chart. Well is using fluid operated valves. Production was 37 bbl of fluid per day (10 per cent salt water). Injection point at bottom valve is 5389 ft. Injected gas-fluid ratio was calculated to be 469 cu ft per bbl. Inlet casing choke is a 3/64-in. positive choke.

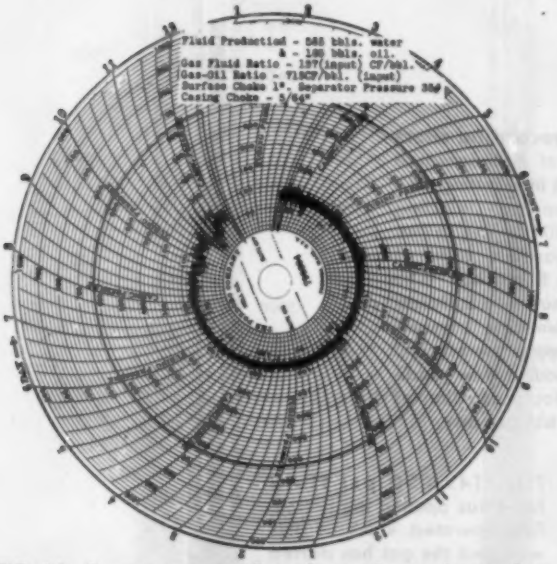

Fluid Production - 568 bbls. water
& - 180 bbls. oil.
Gas Fluid Ratio - 157(input) CF/bbl.
Gas-Oil Ratio - 715CF/bbl. (input)
Surface Choke 1". Separator Pressure 30#
Casing Choke - 5/64"

FIG. 10. **Pressure recording chart** of a continuous-flow type well using fluid operated valves. Production was 750 bbl per day of fluid (76 per cent salt water) with an injection gas-fluid ratio of 157 cu ft per bbl of fluid.

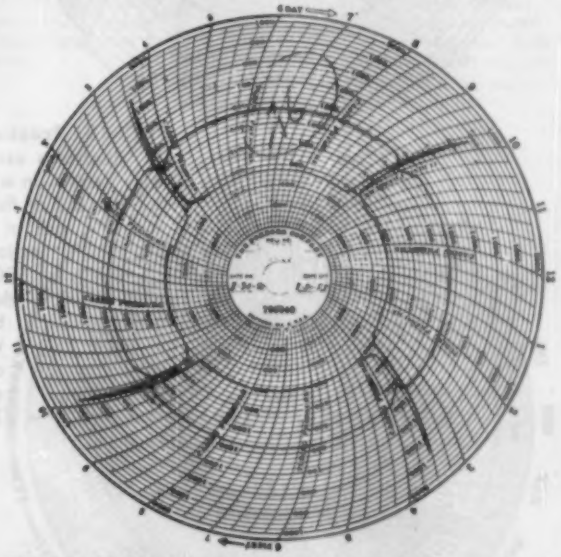


FIG. 11. **Fluid operated valve operation** in a deep, intermittent-type well is illustrated here. Well is producing against high back pressure of 300 psi and 2½ miles of flow line. Well intermitted 8½ bbl of fluid per cycle, injecting gas at 8530 ft, with an injection gas-fluid ratio of approximately 1000 cu ft of gas per bbl of fluid.

Casing pressure at 1950 ft = 471 psi

8. 471 — 392 = 79 psi greater casing pressure than tubing pressure at operating valve.

Therefore, from this well, 450 psi operating gas pressure theoretically can lift 750 bbl per day from 1950 ft against 100 psi surface tubing pressure, or "back pressure."

The actual fluid-operated valve installation was made as follows:

Valve No.	Spacing, ft	Depth, ft	Valve Pressure, psi
1	1010	1010	350
2	472	1482	350
3	465	1947	350
4	322	2269	350
5	207	2476	350

Actual production from this well in February 1956, was 783 bbl per day gross fluid. Input gas-fluid ratio was 98 cu ft per bbl on this production test.

In Well B, the following was known:

Total depth of well, feet	5100
Static bottom-hole pressure, psi, estimated	1835
Productivity Index, bbl per day per psi	Not known
Total production desire, bbl per day	Max. lift capacity
Tubing size, inches—nominal	2½
Casing size, inches OD	7
Gradient of well fluid	Not known
Available kickoff gas pressure	475
Available operating gas pressure	450
Tubing and annulus loaded with salt water	

The well was originally equipped with six specific-gravity-operated type valves to approximately 3000 ft. The valves were lifting 450 bbl per day with an input gas-fluid ratio of 618 cu ft per bbl. No BHP traverses were made while lifting with the specific-gravity-operated valves.

Fluid-operated valves were installed as follows:

Valve No.	Spacing, ft	Depth, ft	Valve Pressure, psi
1	927	927	350
2	434	1361	350
3	433	1794	350
4	307	2101	350
5	309	2410	350

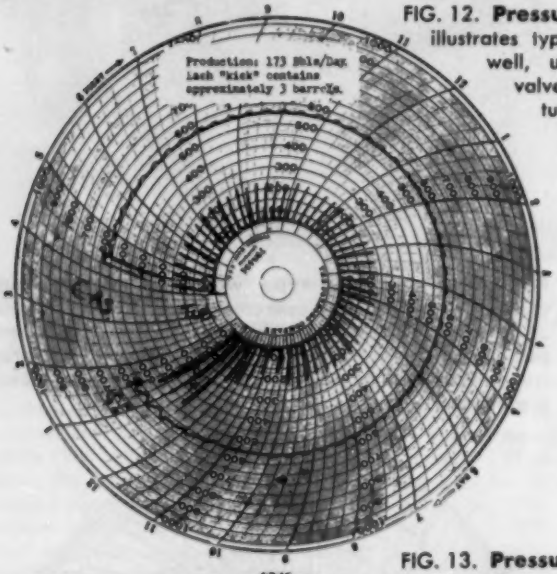


FIG. 12. **Pressure recording chart** illustrates typical intermittent-type well, using fluid operated valves. Sharpness of the tubing "kicks" and uniformity of kicks indicates peak efficiency. Production was 173 bbl of fluid per day (65 per cent salt water).

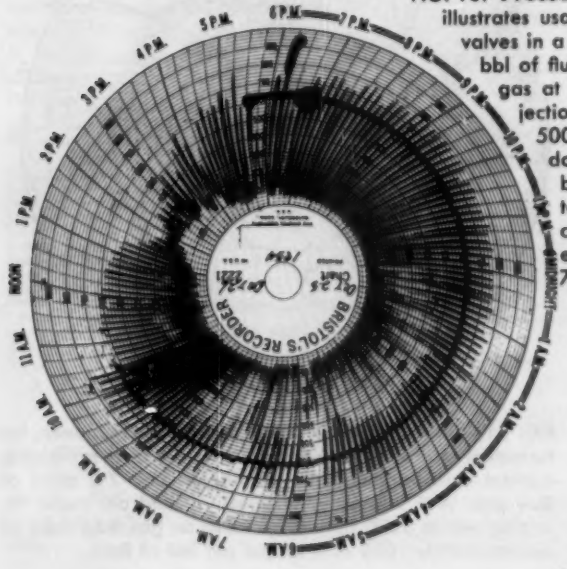


FIG. 13. **Pressure recording chart** illustrates usage of fluid-operated valves in a well intermitting 787 bbl of fluid per day, injecting gas at 3950 ft, with an injection gas-fluid ratio of 500 cu ft per bbl. Well does not have sufficient bottom-hole pressure to support an efficient continuous flow gradient for production of 787 bbl per day.

Illustrating this case is an actual static and flowing bottom-hole pressure traverse (Fig. 2) made after the fluid-operated valves were installed. Production on the test was 485 bbl per day and the input gas-fluid ratio was 100 cu ft per bbl.

Borderline cases. The third well is a borderline case. Well "C" was originally equipped with seven pressure-operated type valves to 3825 ft. The operating valve was at 2200 ft, lifting 347 bbl per day gross fluid (87 per cent salt water) with an input gas-fluid ratio of 450 cu ft per bbl.

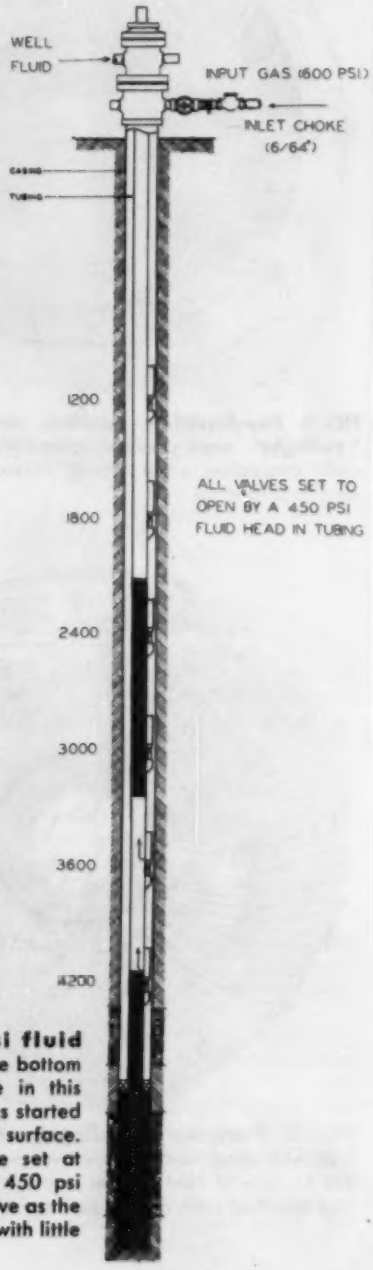


FIG. 14. **450 psi fluid** head has opened the bottom fluid-operated valve in this well, and the gas has started the "slug" to the surface. Since all valves are set at same pressure, the 450 psi head opens each valve as the slug passes upward with little slippage.

Total depth of well, feet	6050
Static bottom-hole pressure, psi	2545
Productivity index	0.65+
Total fluid desired, bbl. per day	600+
Tubing size, inches	2½
Casing size, inches, OD	7
Gradient of well fluid, psi per ft	0.47
Available kickoff gas pressure, psi	650
Available operating gas pressure, psi	640
Tubing and annulus loaded with salt water	

The following is the manner in which the actual installation was made using fluid-operated valves:

Valve No.	Spacing, ft	Depth, ft	Valve pressure, psi
1	1300	1300	540
2	700	2000	540
3	700	2700	520
4	600	3300	520
5	700	4000	520
6	700	4700	520

This well has an intermediate productivity index, so the gas-lift installation was designed to handle either intermittent or continuous-flow operation. The exact productivity index was not known, and percentage of salt water at high rates of flow could only be estimated. No. 3 valve was placed at 3300 ft, calculated maximum depth of continuous flow with 640 psi available operating gas pressure. Two valves were placed below 3300 ft, in case the productivity index was lower than data indicated, and production of well fluid became an intermittent-type lifting operation. Thus, the four valves set at 520 psi would slug the fluid heads as intended in fluid-operated valve design. The two top valves, set at 540 psi, were intended only as unloading valves.

The well intermitted itself for approximately two weeks after being turned on production. But, when the oil percentage rose to approximately 25, the well adjusted to a continuous-flow operation and has remained so to date. Fig. 3, illustrating this, has actual static and flowing bottom-hole pressure traverses plotted vs depth. Using fluid-operated valves, total fluid production on the test in conjunction with the pressure traverse was 700 bbl per day,

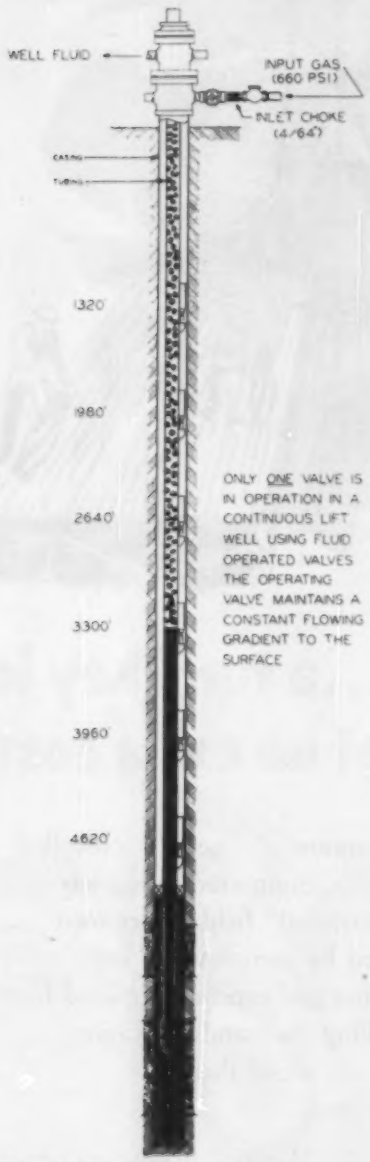


FIG. 15. **Typical installation** of fluid-operated valve in a continuous-flow type well. One valve is in operation.

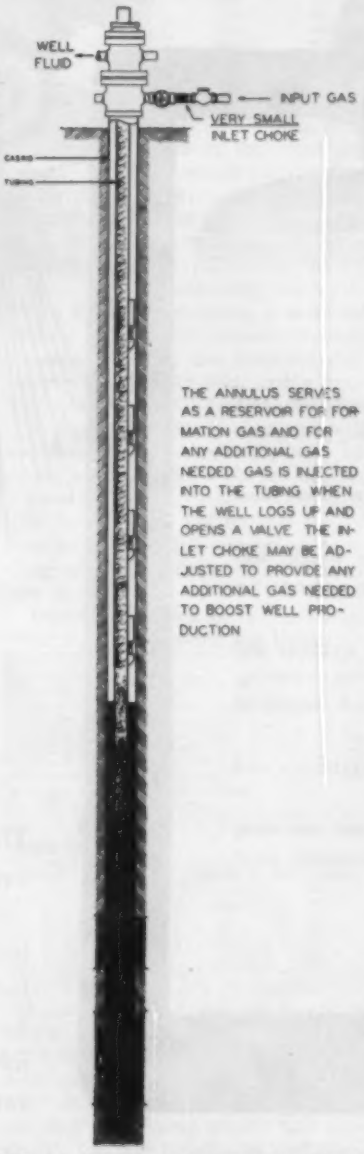

WELL FLUID
INPUT GAS
VERY SMALL INLET CHOKE
CASING
TUBING
THE ANNULUS SERVES AS A RESERVOIR FOR FORMATION GAS AND FOR ANY ADDITIONAL GAS NEEDED. GAS IS INJECTED INTO THE TUBING WHEN THE WELL LOGS UP AND OPENS A VALVE. THE INLET CHOKE MAY BE ADJUSTED TO PROVIDE ANY ADDITIONAL GAS NEEDED TO BOOST WELL PRODUCTION

FIG. 16. **Fluid operated valves** are used here in a well having relatively high formation pressure, but which tend to log up and cease flowing in certain high ratio wells.

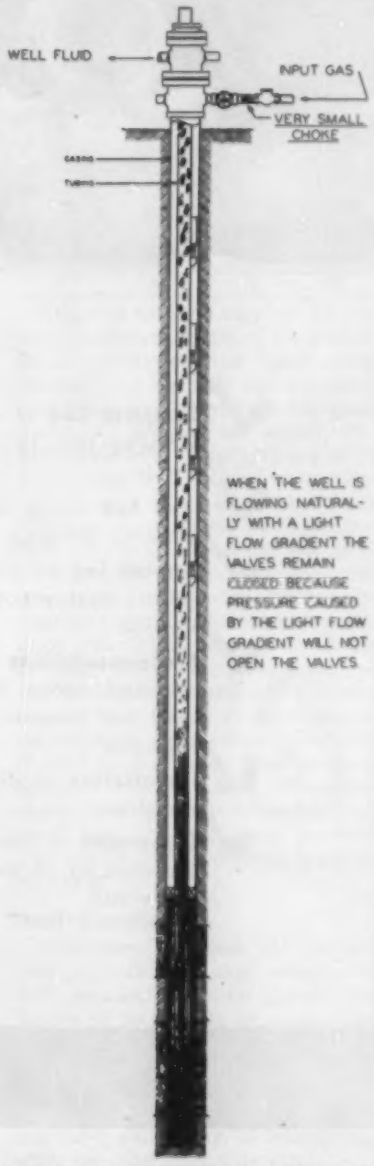

WELL FLUID
INPUT GAS
VERY SMALL CHOKE
CASING
TUBING
WHEN THE WELL IS FLOWING NATURALLY WITH A LIGHT FLOW GRADIENT THE VALVES REMAIN CLOSED BECAUSE PRESSURE CAUSED BY THE LIGHT FLOW GRADIENT WILL NOT OPEN THE VALVES

FIG. 17. **Combination flowing and gas-lift well** here is using fluid-operated valves.

TOOLS + ...

- **Complete Log** of casing run and cementing time for your permanent records
- **Mud Log** during entire casing and cementing operations
- **Cement Log** for proper weight and quality during entire cementing operation
- **Recommendations** for scratcher and centralizer pattern, casing running speed and frequency and length of reciprocation
- **Installation** of all scratchers and centralizers
- **Supervision** of casing and cementing operation by an experienced field service man

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This means . . . quality controlled tools . . . engineered casing job . . . qualified* field service men . . . backed by complete research facilities and experience gained from handling thousands of casing jobs . . . all of this at no extra cost.

WEATHERFORD *Oil Tool Co.*

*Weatherford men receive continuous technical training on an organized basis to guarantee you the best qualified man in the field to handle your casing job.

72 per cent salt water. Injection gas-fluid ratio was 83 cu ft per bbl.

In the fourth well, another border line case, the following was known:

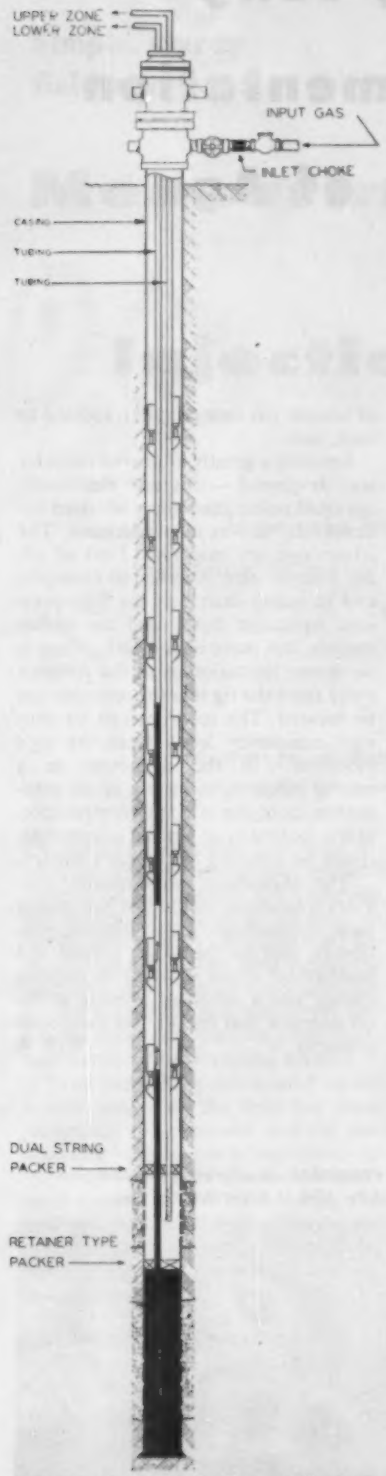


FIG. 18. Typical dual completion installation using fluid operated valves for both tubing strings. The two strings are run parallel in the casing.

Total depth of well, feet	6000
Static bottom-hole pressure, psi estimated	2145
Productivity Index, bbl per day per psi, estimated	1.0
Total production desire, bbl per day, approximately	400
Tubing size, inches—nominal	2½
Casing size, inches—OD	7
Available kickoff gas pressure, psi	640
Available operating gas pressure, psi	640
Tubing and annulus loaded with salt water	

The well was originally equipped with six casing-pressure-operated type valves to 3600 ft, lifting 247 bbl per day gross fluid from the operating valve at 2725 ft. The valves were continuous-lifting the well.

The actual fluid operated valve installation was made as follows:

Valve No.	Spacing, ft	Depth, ft	Valve pressure, psi
1	1200	1200	450
2	525	1725	450
3	500	2225	450
4	500	2725	450
5	500	3225	450
6	500	3725	450
7	475	4200	450

This well has 2½-in. tubing producing into a long 2-in. flow line; therefore, the fluid-operated valves were placed closer than in the "foot per pound" rule to compensate for possible high back pressure should the well go into a continuous lifting phase. The well actually did continuous lift for a short time, but adjusted to a slug-lifting operation in approximately one week. Fig. 4, illustrating this case, is an actual flowing bottom-hole pressure traverse showing pressures that occurred during production with both casing pressure operated and fluid-operated valves.

With fluid-operated valves, the well automatically "intermitted" itself 83 cycles per day with 5.3 bbl per slug for a gross production of 440 bbl per day. The increase was 193 bbl per day of fluid production. The lower-most operating valve in the fluid-operated valves was at 3225 ft.

Intermittent cases. In the fifth case, Well "E," the following was known:

Total depth of well, feet	4000
Static bottom-hole pressure, psi	1760
Productivity index, estimated	0.3
Total production desire	Full well capacity
Tubing size, inches	2
Casing size, inches OD	5½
Gradient of well fluid, psi, per ft	.465
Available kickoff gas pressure, psi	650
Available operating gas pressure, psi	650
Tubing and annulus filled with salt water	
The well was previously on pump	

The actual gas-lift installation was made as follows:

Valve No.	Depth, ft	Spacing, ft	Valve pressure, psi
1	1345	1345	500
2	1945	600	500
3	2545	600	500
4	3145	600	500
5	3745	600	500

This well has a low productivity index. Therefore, the well was valved to as near bottom as possible. Four valves set 650 ft apart would not reach bottom, so five valves were needed and were set 600 ft apart. Maximum fluid per day since being turned into production has been 65 bbl. The well intermits 2.7 bbl per "kick" once each hour (salt water is 40 per cent). The input gas-fluid ratio was calculated to be 650 cu ft per bbl.

Fig. 5 illustrating this case is actual static and flowing bottom-hole pressure traverse. The flowing-pressure traverse was made after a head of fluid was produced into the stock tank and the well-head pressure returned to normal separator pressure. So, it shows the approximate minimum pressures of an intermitting cycle for the well.

The bottom valve opens when tubing pressure opposite the valve builds up to 525 psi and the head is lifted to the surface.

The well was previously equipped with a hydraulic operated pump.

Total depth of well, feet	11,112
Static bottom-hole pressure, psi, approx	3,000
Productivity index, bbl per day per (approx.)	0.02
Total production desired	Well capacity
Tubing size, inches	3(2 inch flow line, 2000 feet length)
Casing size, inches OD	7
Gradient of well fluid, psi per ft	0.45
Available kickoff gas pressure, psi	2000
Available operating gas pressure, psi	1000
Tubing and annulus filled with water for unloading	

The actual gas-lift installation was made as follows:

Valve No.	Spacing, ft	Depth, ft	Valve pressure, psi
1	4000	4000	800
2	2000	6000	800
3	2000	8000	800
4	1000	9000	800
5	1000	10,000	800
6	400	10,400	800

This well having a very low PI was valved within one joint of the packer. On a production test made three months after the well was unloaded, production was 42 bbl per day gross fluid (24.5 per cent salt water). The well makes three "slugs" per day of 14 bbl per slug from the 3-in. tubing. The well is being lifted from the bottom valves at 10,400 ft and the input gas-fluid ratio in the above test was 2970 cu ft per bbl. Fig. 6, illustrating this case, is an actual flowing bottom-hole-pressure traverse of the intermittently-lifted well. When the fluid builds up enough to open the bottom valve, gas will be admitted to the tubing. There is a 24/64-in. choke in the tubing at the well-head, and the flow line is 2500 ft of 2-in. line pipe. The casing is equipped with a small adjustable choke. Even against a tubing choke and small flow line, the input gas-fluid ratio is very low for a lifting depth of 10,400 ft.

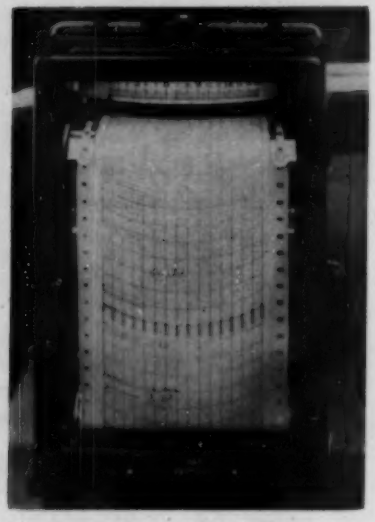
Dual Completions

Fluid-operated valves are particularly adaptable to dual completion wells because the valves provide the feature of being able to successfully utilize a common gas reservoir with satisfactory results. This is true in both intermitting and continuous-flow lift, as well as combinations of both where one valve string may be intermitting while the other constantly lifts.

In the common reservoir system, each string of fluid-operated valves receives its supply of gas from the gas volume chamber as the influx of fluid of its own zone dictates. ★ ★ ★

Casing-Tong Instrumentation Comes of Age

Running casing with a power tong equipped with a tong-torque gage and recorder. The gage works hydraulically; the remote recorder (away from the rig floor) is operated electrically.



Close up of the chart that chronicles every length of casing run, and the amount of torque applied to each.

Hydraulically-operated gage has two pointers, one of which can be set as a target for the other.

A scant year and a half ago instrumentation was introduced to the power tong. Many casing-tong operators enthusiastically accepted the new development, which was a completely hydraulic system consisting of a load cell on the back-up line, a gage on the tong, and a strip-chart recorder a few feet away. The gage indicated the actual number of foot-pounds of torque being applied, and gave the operator a means of making up his joints uniformly and to the exact torque recommended. The recorder provided a written history of the entire operation.

These forward-looking casing-tong operators, noting the long-established practice of other service people (such as acidizers and cementers) of submitting charts at the end of a job, agreed that a similar service would be of great benefit to their operation too. It turned out to be a small but important "something extra" that protected both parties. When a copy of the chart is presented to the oil operator at the end of the job, he can tell exactly the number of joints run, the time elapsed, and the amount of torque (in foot-pounds) applied to each joint.

Recently a greatly improved recorder was developed — this one electrically operated rather than being actuated hydraulically as was its predecessor. The advantages are manifold. First of all, the electric wire is easier to transport and to string than was the high-pressure hydraulic hose used on earlier models. But more importantly, there is no severe limitation as to the distance away from the rig that the recorder can be located. The recorder can be situated completely away from the rig's vibration — in the doghouse, in a nearby office, in the trunk of an automobile, or in any other convenient spot. If it is located in or near an automobile, it can be powered by the car's battery.

The instrument combination provides a practical method of preventing loose connections, galled threads, miscounts, and all the other human and mechanical errors inherent in running casing, and a means of proving to the oil operator that the job has been done properly. ★ ★ ★

Electrically-operated recorder is shown clamped in the trunk of an automobile 100 ft from the rig floor.

FIG. 1. **Water testing apparatus** is securely and compactly fitted in this wood carrying case. Total weight of the kit is 14 lb; it measures 21 by 12 by 5 in.

Simple, sturdy field unit for . . .

Measuring Quality Of Injection Waters

Flow rate through millipore filter indicates tendency of water to plug formations. Collected solids can be analyzed in lab

Martin Felsenthal and B. L. Carlberg
Continental Oil Company, Ponca City, Oklahoma

A portable apparatus has been developed by the production research division of Continental Oil Company for testing the quality of oil field injection waters. This apparatus has been used extensively in the field during the past year. It has proved especially useful for evaluating how effectively suspended solids are removed from injection waters by field treating systems.

Need for testing the quality of injection waters in the field has been recognized for sometime, and the unit described in this article represents an improved version of previously developed apparatus.[1,2,3] In designing the new unit, a particular effort was made to create an instrument that could be easily transported, assembled, and operated in the field.

Equipment and Procedure

Fig. 1 shows the components of the unit securely fastened in place in a wood carrying case. The outside dimensions of the case are 21 in. by 12 in. by 5 in. Total weight is 14 lb. The unit can be set up in a few minutes time in the field. Fig. 2 shows the unit assembled in the field during a water quality test. A diagrammatic sketch of the test assembly is presented in Fig. 3.

The unit is tied into the field water system at any desired point; e.g., ahead of the entire water treating plant, near the upstream or downstream ends of filter installation, or at the injection wellhead. From the tie-in point, water is conducted through a needle valve into a reservoir holding approximately one liter, where a constant pressure equivalent to four feet of water is maintained by means of an overflow arrangement (Fig. 3). Flow lines are arranged so air does not contact the water during its passage through the reservoir. The reservoir itself is supported by a photographic tripod.

During the water quality test, water flows from the reservoir first through a flow meter of about 30-cc per minute flow capacity, and then through a filter element held in a plastic clamp. The filter element is a 47-mm diameter disc having 0.45 micron pore opening, commonly known under the trade name of "Millipore" filter. A new filter is used in every test. An exploded view of the clamp is shown in Fig. 4. Effluent from the filter is collected in a graduated cylinder.

Flow meter allows rapid determination of flow rates; however, when water contains entrained gas, the flow meter must be by-passed and rates determined with the aid of a stop watch and graduate. Time required in the field for either type of test is generally about 30 minutes. Field experience has shown that the "Millipore" type filter is more sensitive for measuring the relative cleanness of water and is many times less costly to use than other filter elements (e.g., fritted glass) previously employed in water quality tests.

Test Results

Test unit permits collection on the filter element of practically all suspended material in the water. This material can subsequently be examined and analyzed by various tests (chemical, bacteriological, X-ray, et cetera). Results of these studies are a valuable aid in formulating measures to minimize or eliminate troublesome suspended material from the water.

Test unit also indicates the plugging tendency of the water. This tendency can be inferred from a study of the flow rates obtained during a test. Typical flow rate data are shown in Fig. 5. Data for both curves were obtained

FIG. 2. **One liter reservoir,** supported by a photographic tripod, takes water from any point in the field water system through a needle valve. Flow lines are arranged so air does not contact water during passage through the reservoir.

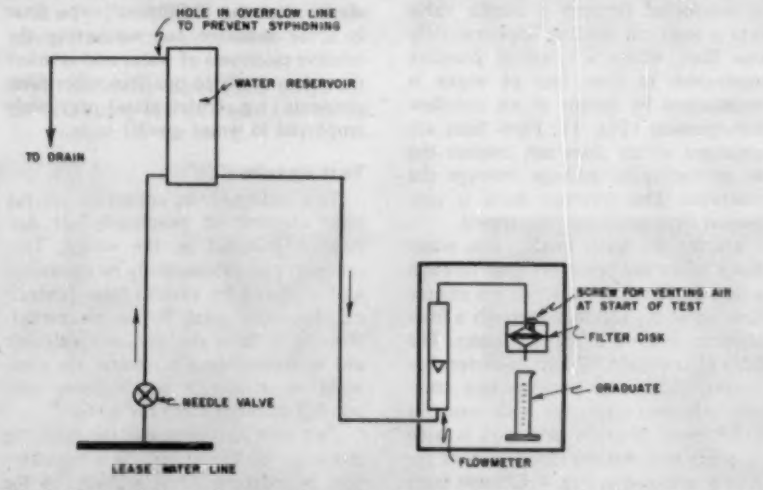


FIG. 3. **Assembly and operation** of water quality test equipment is illustrated in this diagram. Water reservoir is positioned so that a constant pressure equivalent to 4-ft head of water is maintained by means of an overflow arrangement.

under identical test conditions. It is evident that curve A is less steep than curve B. From this it is concluded that water A has less tendency to plug the sand face of an injection well than does water B and, therefore, is considered to have a better quality for injection purposes.

Studies of flow rate data and examination of solids picked up by the filter indicate the quality of the water only at surface conditions. Further studies may, therefore, be needed for some water injection projects to ascertain whether or not additional solids will become suspended in the water as a result of corrosion or bacterial growth in the well, precipitation of calcium carbonate at down-hole temperature and pressure,[4] and incompatibility of the injection water and the formation water.[5] Further studies also may be needed to determine whether or not the injection water is compatible with the formation clays.

Application of Results

With the above limitations in mind, test results can be used as an aid in selecting the best of several injection waters if there is a choice of waters. Furthermore, test results can be used for evaluating the effectiveness with which treating systems remove suspended solids from the water before and after it has passed through the system (Fig. 5). The above procedure can, of course, be applied to any part of a treating system. For instance, it was used recently with evident success for selecting the best available commercial filter for a large water injection project. Last but not least, following the initial evaluation, a check can be maintained with the aid of the test unit on the day-to-day quality of the water at any point in the treating system.

Possible Additional Application of Data

Shape of flow decline curve. Further studies now in progress may reveal additional useful applications of water quality data. It has been noted, for instance, that the semilogarithmic graph of Fig. 5 does not always indicate a straight line ("decay" type) function; however, the very fact that some of the curves deviate from a straight line function may be significant and possibly could provide important clues regarding the size, shape, and other characteristics of the plugging material.

Water quality number. It is sometimes desirable in routine tests to characterize the water quality curves by a single number. This number to be useful must be easy to obtain. A convenient way in which this might be accom-

FIG. 4. **Clamp for "Millipore" filter disc** is exploded to show component parts. Filter disc, not shown, is placed between perforated plastic support disc and neoprene O-ring.

plished would be simply to observe the per cent flow decline indicated by the test unit in a given period of time; e.g., 30 minutes. To make the proposed flow decline number comparative from test to test, a standard initial flow rate (e.g., 20-cc per minute) is needed. For instance, with the aid of this device, we can designate the flow decline numbers for the previously described waters A and B as 5 and 59 per cent, as illustrated in Fig. 6.

The use of flow decline numbers instead of curves would greatly simplify the routine description of the day-to-day quality of a given water. There are, however, situations in which the flow decline curves will be of value. For example, in initial evaluations of new water systems, it is advisable to collect sufficient data to plot complete flow decline curves. The shapes of the curves then can be analyzed for their possible significance. Numerous tests should be performed for this purpose.

Water quality requirements. One important use for the test results would be to compare the quality requirements of waters used in various oil field injection projects. It is realized from the outset that quality requirements are different for various projects. Field experience has shown that a low quality (high flow rate decline) water suitable for injection into an open or high permeability formation can prove detrimental to a tight or low permeability formation.

Adoption of a standardized water quality test yielding universally understood water quality designations is believed to be almost a prerequisite for compiling information on water quality requirements and for maintaining desired water quality standards in the field.

Aids for Obtaining Test Results

Flow meter calibration curves (scale reading vs flow rate) are affected to some extent by temperature and salt content of the water. Corrections for these variables could be made conveniently with the aid of a nomograph.

A scale directly indicating the proposed water quality number (expressed as per cent flow decline) can be constructed and affixed to the flow meter, provided the water to be tested is similar to the water used for calibrating the scale. Multiple scales are needed if appreciable temperature or salinity changes are anticipated.

Conclusions

An apparatus has been developed and field tested for determining the quality of water. The apparatus has proved useful for selecting water possessing the least plugging tendency and for evaluating how effectively field treating systems remove suspended solids from the water. Field experience has indicated that the apparatus is more economical to use, affords

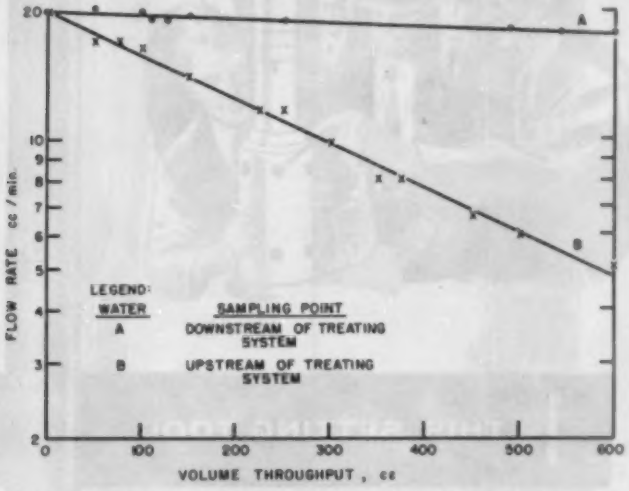


FIG. 5. **Typical flow rate data** indicate plugging tendency of the water. Note that curve A is less steep than curve B. It is concluded that water A has less tendency to plug the sand face of an injection well than B.

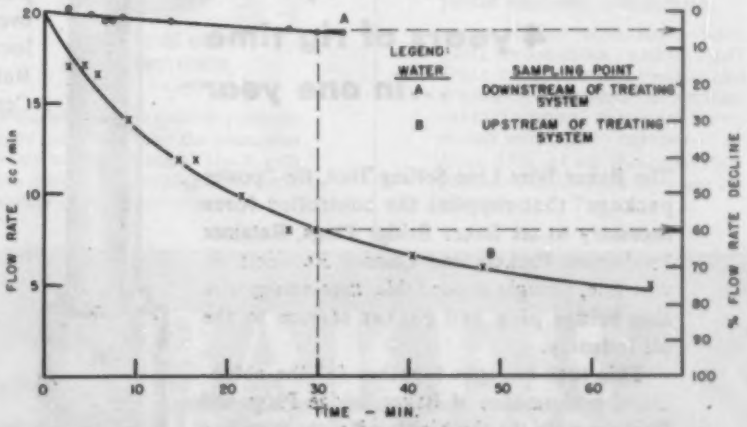


FIG. 6. **Water quality data** are sometimes desirable using a single number. This is accomplished by observing the per cent flow decline indicated by the test unit in a given period of time. Flow decline of waters previously described in Fig. 5 were designated as 5 and 59 per cent.

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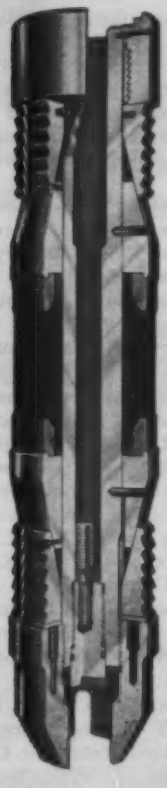

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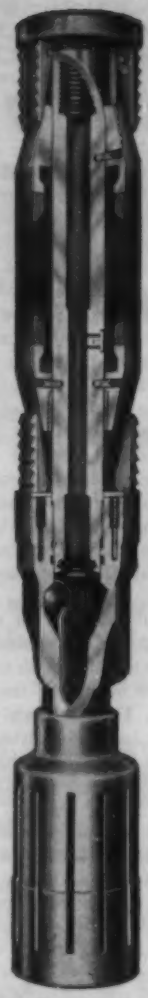

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Martin Felsenthal received his BS degree in petroleum engineering from the University of California in 1940 and his MS degree in the same field from Pennsylvania State University in 1949. He was research librarian for the Esso Research and Engineering Company from 1946 to 1947 and became a research assistant at Pennsylvania State in 1947. He joined Continental Oil Company in 1949 as a research engineer. He is a member of the AIME.

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higher sensitivity for measuring cleanness of water, and is easier to carry, set up, and operate in the field than similar instruments previously used in this type of test.

Acknowledgment

The authors wish to thank the management of Continental Oil Company for permission to publish this article.

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Oil Well Cementing Association Forms

The Independent Oil Well Cementing Association of America has been organized with Boyd Brazeel, Graham, Texas, named as president.

Fred Lynch, Seminole, was elected vice president, and Johnnie Weaver, Oklahoma City, secretary-treasurer.

The association was organized to help companies keep pace with the latest developments and to share technical advances.

Drilling Technology School Enters Fifth Session

Classes start in October for 30 oil men who are enrolled in the fifth session of the School of Drilling Technology at Odessa, Texas, sponsored by the American Association of Oilwell Drilling Contractors.

International in scope, the six-week course has attracted the world-wide attention of the drilling industry to the campus of Odessa Junior College. Since the first class in the fall of 1954, nearly every oil producing nation of the free world has beeen represented at the school, as well as every active oil area of the United States. Students from Iraq, Venezuela, and Bolivia are among the registrants for the 1956 fall session.

Basic outline of the fifth session remains the same as for the previous schools, covering practical subjects ranging from economics to mechanics. Major changes in the fall course concern the classes on geology, which have been revised to emphasize practical information needed by the man on the rig.

The curriculum for each school is planned by an AAODC general advisory committee together with the Petroleum Extension Service of the University of Texas. The advisory group is headed by H. Jack Haberlein, drilling superintendent for Schoenfield-Hunter-Kitch Drilling Company, Tulsa, Oklahoma.

The school is designed to review current operating practices in oil well drilling, and to offer the students an advance look at new developments in equipment and technique. The concentrated course moves fast to cover 19 subjects during the 180 hours of study — virtually the equivalent of two years of college instruction, in the estimation of Richard L. Dailey, school coordinator for "Petex."

Classroom sessions are supplemented by Saturday field trips arranged by contractors and producing companies to enable the students to see in operation the tools they have been discussing. The School of Drilling Technology has also had the full cooperation of manufacturers in furnishing equipment models for classroom demonstration, and supplementary texts and literature.

The School of Drilling Technology has been called "one of the proudest achievements of the AAODC," by E. Dale Mount, 1955-56 president of the association and vice president of Harry Bass Drilling Company, Dallas, Texas.

Each man at the School of Drilling Technology is sponsored by the company for whom he works and is, in effect, a "scholarship student." His company pays the $300 tuition, as well as salary, living expenses and transportation to and from Odessa. In the case of a foreign student, this can easily amount to a $3000 investment in education.

A representative class includes drilling engineers, drillers, toolpushers, and service engineers. About half the enrollment is made up of employees of oil producing companies, with the remainder from contract drilling firms and suppliers. At the end of six weeks of classroom and field instruction, the men earn "hard hats" bearing the AAODC emblem — the oil industry's mortar board symbolizing graduation from the school.

With enrollment limited to 30 men, classes are always filled well in advance. More than one-third of the places available have been reserved for the spring term, which starts February 4, 1957.

The fall session began Monday morning, October 1, with a review of the scope of the drilling industry by AAODC President Mount. The next four days were devoted to a study of management and supervision, with conferences led by M. L. Powers of the University of Oklahoma.

In addition to Mount and Powers, instructors at the fifth session include Jerry Wilson, Caterpillar Company; Glenn W. Webb, General Electric Company; Eugene Colleoni, Detroit Diesel; A. A. Ashton, Emsco Manufacturing Company; Ross Colebrook, National Supply Company; Carrol Kelso, Martin-Decker Corporation; Bill Taylor, Westinghouse Air Brake Company; W. K. Thorson, IDECO; Bob Farmer, Cameron Iron Works; and Ty Gibbs, Bethlehem Steel Corporation.

Other instructors are Clem H. Roberts, Delta Gulf Drilling Company; Wiley Noble, Reed Roller Bit Company; Lyle Payne and Henry Woods, Hughes Tool Company; Bob Stuart, Diamond Oil Well Drilling and Service Company; Q. B. Marsh, Sperry Sun Well Surveying Company; Philip L. McLaughlin, Cardwell Manufacturing Company; Bill Redman, Oilwell Supply Company; R. L. Whiting and John R. Pedigo, Texas A & M College; Tom Keating, Stanolind Oil & Gas Company; Jim Conway, University of Texas; and Waldo Grossman, Baker Oil Tool Company.

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The Unsteady-State Behavior of Linear Gas-Storage Reservoirs

More efficient use of available storage can be made when its behavior is known. Here is a mathematical approach

Joseph E. Warren
Gulf Research & Development
Pittsburgh, Pa.

As a direct result of vast increases in utilization of natural gas, storage reservoirs have become an economic necessity. This storage capacity permits optimum operation of transmission lines and provides the flexibility that distribution systems require to meet peak loads. To enable intelligent use of available storage, a correct mathematical description of the reservoir behavior is essential, i.e., the pressure-distribution history under expected operating conditions.

Since operating procedures are dictated by fluctuating demands, steady-state behavior is virtually non-existent in storage reservoirs; therefore, the transient solutions to the governing flow equations are of primary importance. The governing equation for the flow of gas in a reservoir is a second order, non-linear partial differential equation of the parabolic type. As such, it has no known analytic solution and must be either linearized by simplifying assumptions or solved by numerical methods. Linearization of the equation severely limits the usefulness of the results; consequently, a numerical solution is more satisfactory. Because the calculations involved in this type of solution are highly repetitious, they are most easily handled by a digital computer. Several types of numerical solutions[1, 4, 5, 9] have been employed successfully on this and similar problems, but the choice of a method is restricted by the adequacy of the available computing machinery.

The Problem

Certain assumptions are necessary to facilitate formulation of the problem. They are:

1. Homogeneous and continuous rock properties (porosity and permeability).
2. Isothermal, laminar flow of a gas having a uniform composition.
3. Negligible gravity effects.

In addition to these general assumptions, initial conditions, boundary conditions and a flow pattern must be assumed. A study of existing storage reservoirs indicates that a closed, linear, horizontal system with a constant pressure at the outlet will constitute an adequate model for a typical gas storage reservoir. Since a practical range must be assigned to each variable, pressures up to 2000 psi, temperatures up to 280 F and gas gravities from .55 to .80 will be considered representative.[14] Initial pressure distribution will be assumed uniform; and, due to the pressures and permeabilities encountered in practical cases, the Klinkenberg effect will be ignored.

Combining the continuity equation for a linear, porous system with Darcy's law and the equation of state for a gas that deviates from the perfect gas law, the following equation is obtained:

$$\frac{\partial}{\partial x}\left(\frac{PZ}{\mu}\frac{\partial P}{\partial x}\right)=\frac{\phi}{K}\frac{\partial}{\partial t}\left(\frac{P}{Z}\right) \quad \ldots\ldots\ldots (1)$$

In this equation, Z and μ are functions of temperature and pressure that are determined by the initial conditions, boundary conditions and the gas gravity.

If the dimensionless variable, F, is defined as $\frac{P}{ZP_e}$ (Fig. 1) and it is assumed that Z is a linear function of pressure within the range of interest, equation (1) becomes

$$\frac{\partial}{\partial x}\left(\frac{PZ}{P_{e}\mu}\frac{\partial F}{\partial x}\right)=\frac{\phi}{KP_e}\frac{\partial F}{\partial t} \quad \ldots\ldots\ldots (2)$$

Replacing μ by $\mu_a\left(\frac{\mu}{\mu_a}\right)$[10] and normalizing the equation in F by replacing F with $F/F_{max.}$ ($F_{max.} = F_1$ for withdrawal and $F_{max.} = F_e$ for injection), equation (2) may be rewritten as

$$\frac{\partial}{\partial x}\left[\ f\left(\frac{F}{F_i}\right)\frac{\partial}{\partial x}\left(\frac{F}{F_i}\right)\right]=\frac{\mu_a\phi}{KP_e}\frac{\partial}{\partial t}\left(\frac{F}{F_i}\right) \quad \ldots (3)$$

It is now assumed that $f\left(\frac{F}{F_i}\right)$ may be approximated by a linear function over the range fixed by the initial and boundary conditions assumed for a given problem; e.g., Fig. 3 is obtained from Fig. 2 when the operating limits are fixed.

$$\frac{\partial}{\partial x}\left\{\left[\ a+b\left(\frac{F}{F_i}\right)\right]\frac{\partial}{\partial x}\left(\frac{F}{F_i}\right)\right\}=\frac{\mu_a\phi}{KP_e}\frac{\partial}{\partial t}\left(\frac{F}{F_i}\right) \quad \ldots (4)$$

Equation 4 reduces to the perfect gas solution of Aronofsky and Jenkins[1] when $a = 0$, $b = \frac{P_i}{P_e}$ (perfect gas plot in Fig. 3), $Z = 1$, $\frac{\mu}{\mu_a} = 1$ and μ_a is the average viscosity.

Defining new dimensionless variables as $X=\frac{x}{L}$, $T=\frac{KP_e\,(a+b)\,t}{2\mu_a\,\phi\,L^2}$ and $J=\frac{a+b\left(\frac{F}{F_i}\right)}{a+b}$, equation (4) takes the form

$$\frac{\partial^2}{\partial X^2}(J^2)=\frac{\partial J}{\partial T} \quad \ldots (5)$$

Equation (5) must be solved subject to the following conditions:

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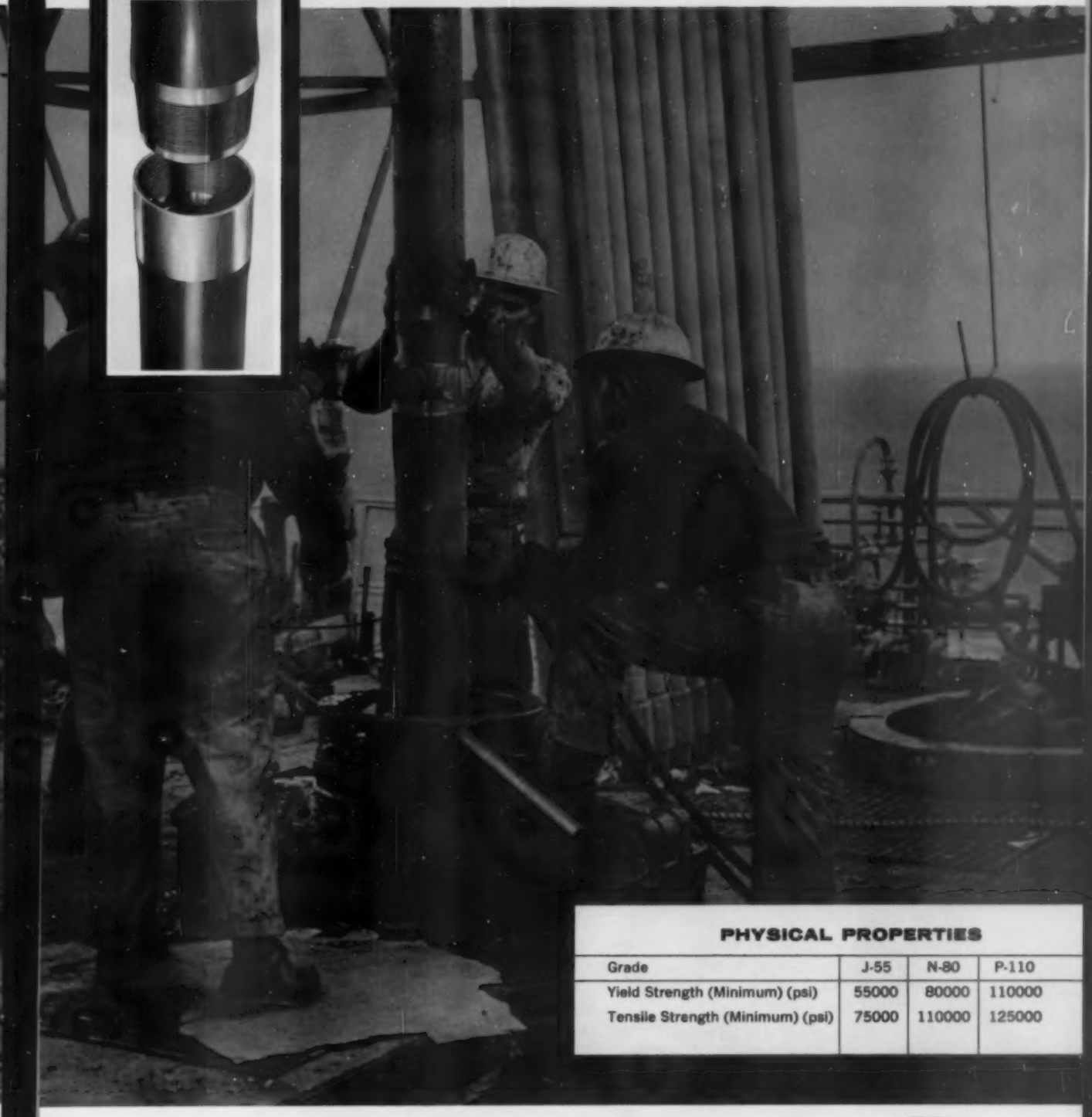

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$$J(X,o) = J_i = \text{constant}$$
$$J(O,T) = J_o = \text{constant}$$
$$\frac{\partial J}{\partial X}(1,T) = O \qquad (6)$$

When the original pressure (P_i), the terminal pressure (P_o), the gas gravity (G), reservoir temperature (R), and the physical dimensions of the system (ϕ, K, L) are known, the reservoir can be reduced to the model shown in Fig. 4 if it approaches a linear system, i.e., when uniform cross-sectional area length is greater than width and the injection and/or production wells located near the extremities. The solutions to (5) subject to the conditions of (6) can be characterized by a single parameter. This parameter is $\frac{J_o}{J_i}$ for withdrawal of gas and $\frac{J_i}{J_o}$ for injection of gas; for each value of the parameter less than 1.0, a unique numerical solution exists.

Method of Solution

Two general types of numerical solutions can be employed when dealing with (5); these are the implicit[4, 5, 7, 8, 9] and the explicit[1, 10, 11] solutions. The implicit solution is more stable than the explicit — larger time-steps may be used without excessive rounding error growth — but the implicit solution also requires reasonably large memory capacity in the computer. Because of the lack of high-speed memory in the available computer (IBM Card Programmed Calculator), the explicit method of solution is used.

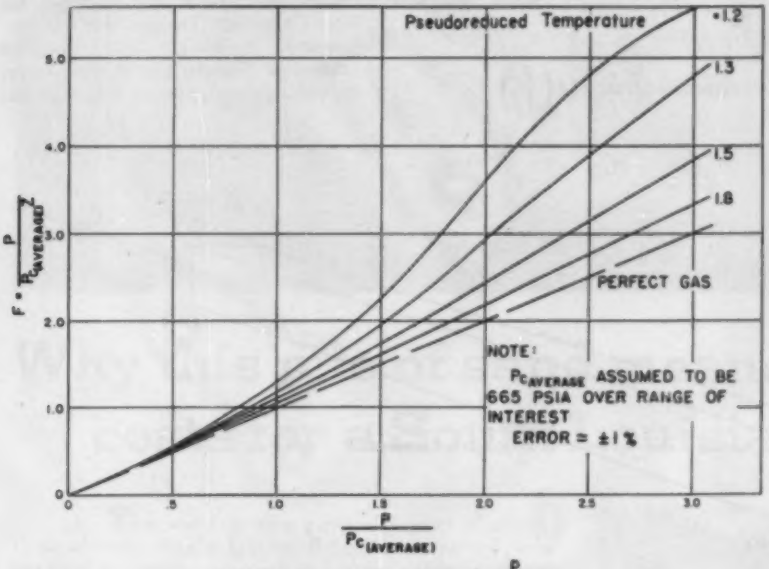

FIG. 1. F as a function of $\frac{P}{P_{C\ ave.}}$

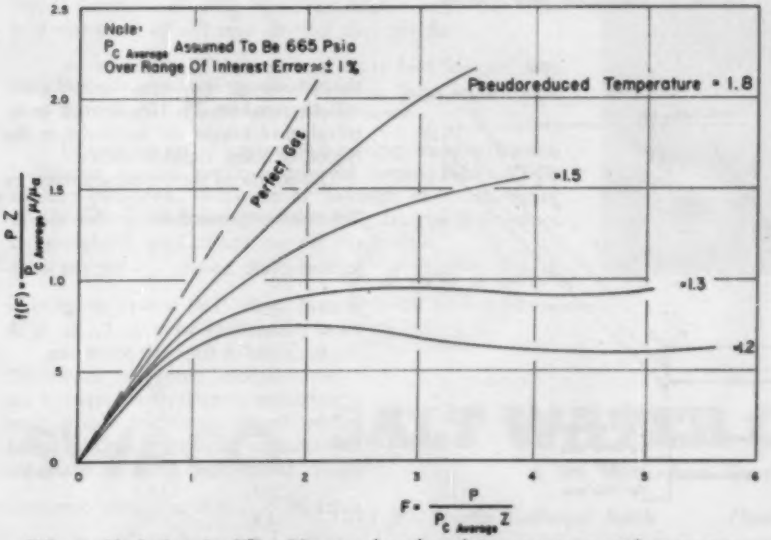
Note:
Pc Average Assumed To Be 665 Psia
Over Range Of Interest Error = ± 1%
Pseudoreduced Temperature = 1.8
Perfect Gas
1.5
1.3
1.2
f(F) = P Z / Pc Average M/Ra
F = P / Pc Average Z

FIG. 2. Variation in f(F) with pseudoreduced temperature and pressure.

Expressing the partial derivatives in finite difference form and neglecting the terms of higher order than the derivatives themselves, equation (5) and the condition of (6) may be approximated in the following manner for the withdrawal cycle:

$$J_{X,T+\Delta T} = \lambda[J^2_{X+\Delta X} + J^2_{X-\Delta X} - 2J^2_X]_T + J_{X,T} \quad (\text{for } 0 < X < 1) \qquad (7)$$

$$J_{X,T+\Delta T} = \lambda[J^2_{X-\Delta X} - J^2_X]_T + J_{X,T} \quad (\text{for } X = 1) \qquad (7)$$

$$J_{o,T} < 1.0 \qquad (7)$$

$$J_{X,o} = 1.0 \qquad (7)$$

$$\text{where } \lambda = \frac{\Delta T}{(\Delta X)^2}$$

The above equation is a four-point predictive form that permits the calculation of the values for the "T + ΔT" time-step if the values of the "T" time-step are known. Equations having the form of the one under consideration are subject to two major restrictions if reliable results are to be obtained. In the first place, ΔT and ΔX must both be sufficiently small so that truncation errors are negligible; secondly, the ratio of ΔT to $(\Delta X)^2$, λ, must be small enough to insure "computational stability." Both of these sources of error must be investigated before the problem can be programmed for computation.

(a) An analysis of the growth of rounding errors is necessary whenever a difference equation is applied repeatedly over a large number of time steps. The method based on[10], in which a linear, parabolic equation for the error is obtained, leads to this expression for error amplification, at a point, between successive time-steps "T" and "T + ΔT":

$$A_X = 1 - 8J_T\lambda \sin^2\left(\frac{m_X \Delta X}{2}\right) \qquad (8)$$

where J_T = average J in the "T" time-step.

If $|A_X|$ is less than 1 for all X, there will be no error growth. This inequality is satisfied for all X if $\frac{1}{\lambda} \geq 4\,J_T$. Since $J_T \leq 1$, the condition for stability is

$$\lambda \leq .25 \qquad (9)$$

An amplification factor greater than one will result in the growth of rounding errors and eventually to an unstable condition in which the significance of the results is completely lost.

(b) Truncation error results from dropping the higher order terms of the Taylor expansion from which the finite difference approximations for the derivatives were obtained. This error can be

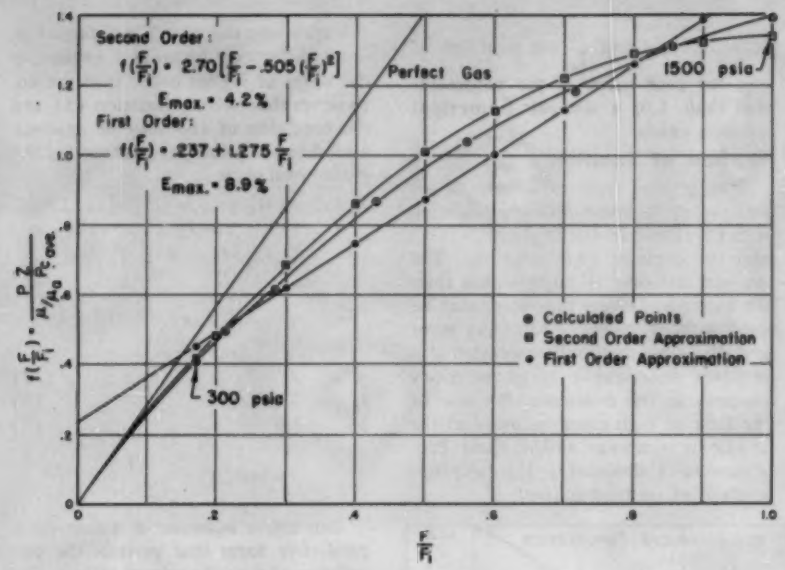

FIG. 3. First and second order approximation of $f\left(\frac{F}{F_i}\right)$

minimized by making ΔT and ΔX very small. By holding λ constant at .25 and varying the value of ΔX, actual computation indicates the truncation error in the X-direction. With $\Delta X = .10$, the error introduced was of the order of one part in 10,000; since this is more accurate than actual field measurements, this increment gives adequate resolution. The requirement that $\Delta T \leqslant .25\ (\Delta X)^2$ is sufficient to fix ΔT_{max}. computation was again employed to determine the truncation error of the T-direction. It was found that a ΔT of .00125 was necessary for accuracy of one part in 10,000 up to T=.10; beyond that point $\Delta T_{max.}$ could be used.

Results. A series of solutions to equation (5) were obtained by means of the C.P.C. installed in the accounting department at the Pennsylvania State University. The machine was programmed for 8-digit, floating-decimal arithmetic. For the first 80 time-steps, the constant multiplier, λ, was .125; for

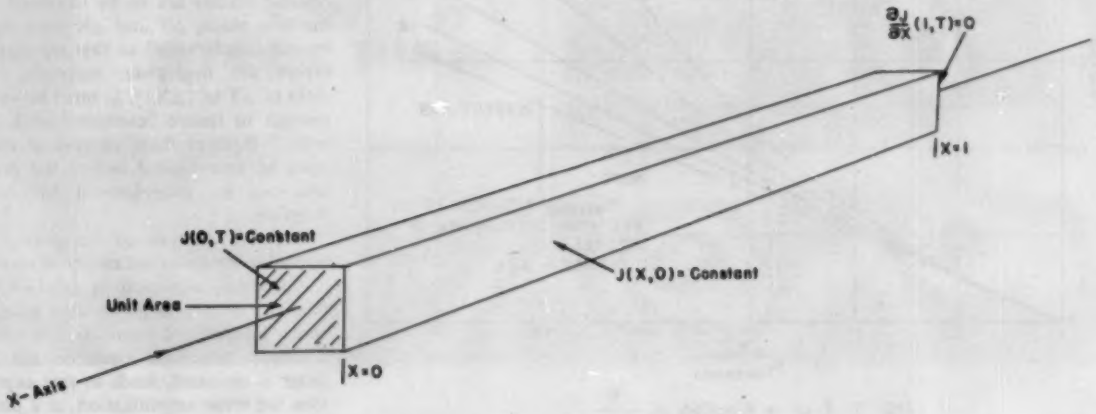

FIG. 4. Idealized flow system.

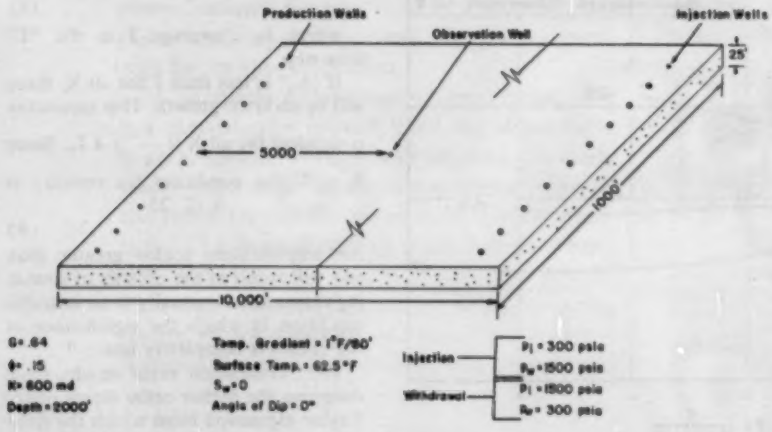

FIG. 5. Example storage reservoir.

the remaining time-steps, the multiplier was changed to .25. This change in interval gave maximum accuracy in the region of most rapid variation.

The solutions were characterized by the values assigned to $\frac{J_i}{J_o}$ for the injection cycle and to $\frac{J_o}{J_i}$ for the withdrawal cycle. The values assigned to these parameters were 0, .1, .2, .3, .4, .5, .6, .7 and .8 for both processes.

Some selected numerical results with a maximum computational error of one in the fourth significant figure, were tabulated to facilitate their use. In addition, the average value of J and the value of $\frac{\partial J}{\partial X}$, at $X = 0$, were computed and listed for each time-step.

Why this pile of sand means lower drilling costs for a South Louisiana operator

The sand in this picture is part of nearly 1500 barrels that a Dorrco D-Sander removed from the mud in drilling one well in South Louisiana. Notice the sharpness of the cliff-like edges which show that the D-Sander not only removes coarse sand but also a great deal of silt and drilled clay solids.

As a result of this, pump parts last longer, bits drill faster and last longer, drilling time is reduced and the cost of mud chemicals is lower.

In one series of controlled comparisons a Dorrco D-Sander saved an average of more than 5,000 dollars per well. Because of savings like this, more and more contractors are installing Dorrco D-Sanders as standard equipment on all their rigs.

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Three Man Crew"

Using a completely portable Cardwell Model AL rotary rig, equipped with a Cardwell Model 100 mast, Arnold L. Lewis—doing business as Lewis Drilling Company out of Princeton, Indiana—has found "reduced manpower . . . drilling equipment . . . and hole size makes Slim Hole Drilling with Cardwell equipment the most economical and efficient method for both producer and drilling contractor."

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Cardwell's Model AL, a single engine mechanical driven hoist, has a Slim Hole depth rating of 4,000 feet using 2⅞ inch drill pipe. For rotary drilling, depth rating is 2,000 feet with 4½ inch drill pipe or 2,500 feet with 3½ inch drill pipe. As a servicing or rotary workover, the rating is to 5,000 feet. Nominal input rating of the Model AL is 120 horsepower. New alloy steels make the unit tougher . . . but lighter. It is specifically designed to combine fast operating speeds with extreme portability.

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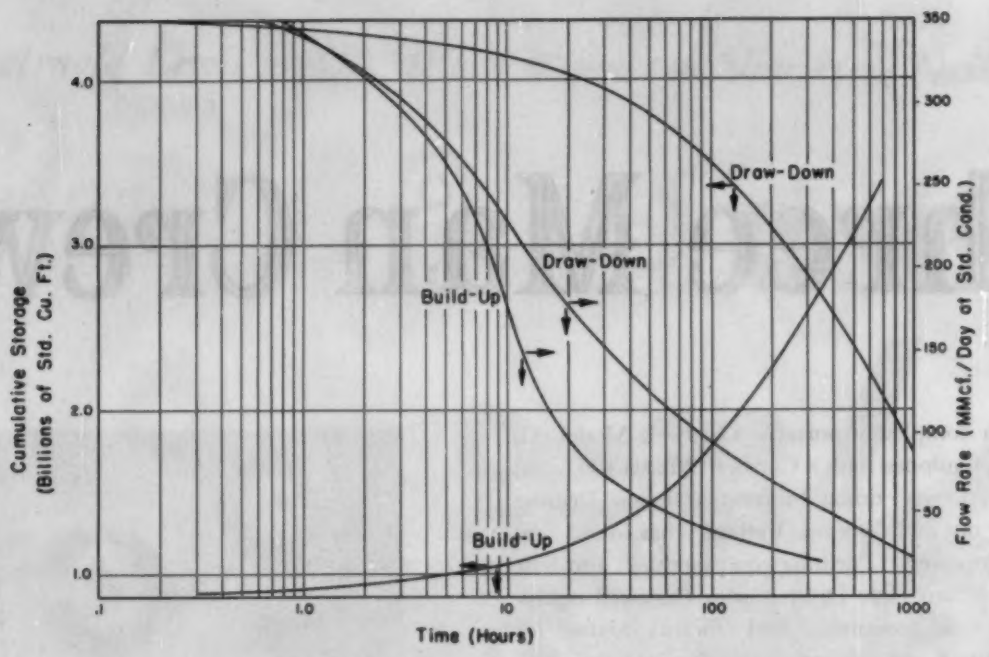

FIG. 6. Cumulative storage and flow history.

Results for draw-down to T = .5 are contained in Table 1; the build-up results to T = .3 are found in Table 2.

Example. To illustrate the practical significance of the dimensionless results obtained, the performance of a typical gas-storage reservoir will be analyzed. The parameters and the operating conditions assumed are hoped to be representative of at least some of the existing storage reservoirs. (The results are equally applicable to primary production reservoirs if the conditions imposed on the solution are met.) Fig. 5 represents the idealized system.

From the data given in Fig. 5, P_c is 669 psi and T_c is 372R; therefore, the reduced temperature, R_s, is 1.5 and the reduced pressure, P_R, varies between .449 and 2.24. The viscosity at one atmosphere of pressure and reservoir temperature, μ_a, is .0107 cp. Correcting for the compressibility, the cushion of gas at 300 psi is .75 billion standard cubic feet; and the total volume at 1500 psi is 4.44 billion standard cubic feet at 16.55 psi and 60 F.

Before continuing, a comment on the justification for assuming a linear system is in order. Strictly speaking, the system described can only be considered linear if there is an infinite number of wells. To investigate the effect of a finite number of wells; e.g., 5 wells with 200-ft spacing, a solution for the pressure distribution at a fixed time was obtained by the relaxation method.[13] This solution indicated that all radial effects were dissipated at a distance of 500 ft from the line of wells (5 per cent of total volume), and the region of noticeable disturbance was limited to 250 ft. Main effect of this distortion is felt in the early history — especially with respect to production rates. The problem can be handled approximately by using a conformance factor or by shifting the origin and solving both the linear and the distorted cases (this solution would also involve a time delay in the linear portion). Either method involves considerable complication of the problem. No attempt will be made here to correct results for the effect of a finite number of wells.

From Fig. 1, F values are found that correspond to the pressures over the range of interest (average P_c values are used in this plot; however, in view or the error introduced from other approximations, this error is very minor). These F values are then used to obtain the magnitudes of f (F) from Fig. 2. The f (F) values are then plotted against F/F_1 as shown in Fig. 3. The next step is to fit the "best" linear function to the curve; the "best" fit in this case is that in which the maximum error is minimized (Chebyshev concept.[11, 12]) The a and b values obtained from the linear function, (a + bJ), provide the final information needed to solve equation (5) subject to (6).

For the injection cycle:

$$J(X,O) = J_1 = .30$$
$$J(O,T) = J_o = 1.0$$

The numerical solutions are then obtained from Table 2 for $\frac{J_1}{J_o} = .30$.

For the withdrawal cycle, $\frac{J_o}{J_1} = .30$ and the numerical results are obtained from Table 1.

To use the results, the transformations from dimensionless variables to real variables must be made. Dimensions used are feet, hours, pounds per square inch absolute, millidarcy, centipoise, and degree Rankine.

(1) A linear transformation exists between J and F; i.e.,

$$F = \frac{F_1}{b}[(a+b)J - a];$$ using Fig. 1, P (psi) can be obtained from F.

(2) $$t \text{ (hours)} = (2.78 \times 10^3)\frac{\phi L^2 \mu_a}{KP_c(a+b)}T = (1.152 \times 10^3)T$$

(3) $$x \text{ (ft)} = XL = (10^4)X$$

(4) Assuming parallel flow elements of unit cross-sectional area,

$$q(\text{MMCF/DAY})_{@\ \text{Std. Cond.}} = .182\left(\frac{P_o R_s}{P_s R_o Z_o}\right)\left(\frac{K}{\mu_a}\right)\frac{P_1(a+b)Z_o^2}{bLZ_1}\frac{\partial J}{\partial X}(O,T)$$
$$= (35.61)\frac{\partial J}{\partial X}(O,T)$$

(5) $$\text{Cum. Storage (Billions of std. cu ft)} = 4.44\left(\frac{P_{ave.}}{1500}\right)$$

Due to assumed linearity, $P_{ave.}$

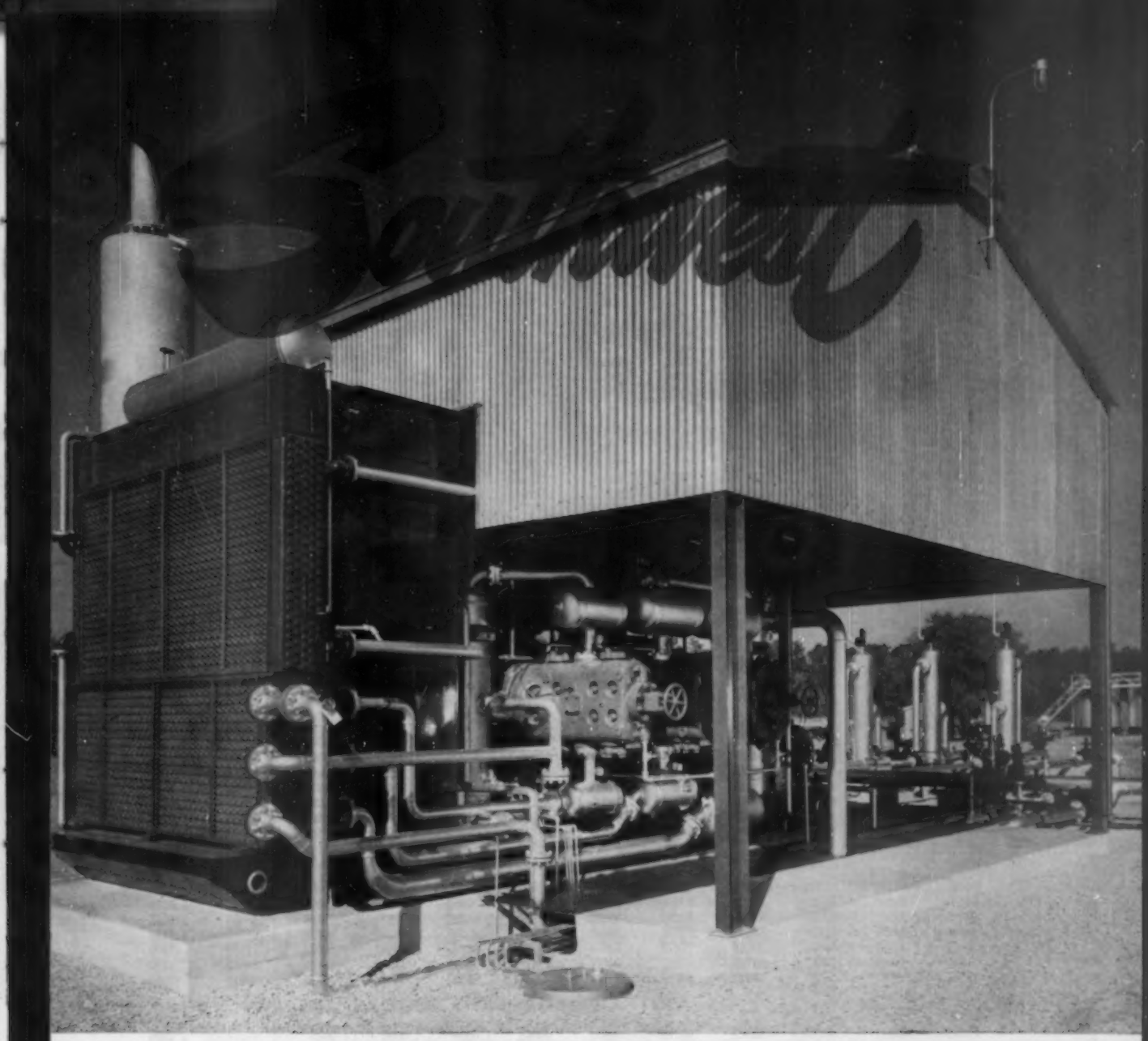

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TABLE 1.
(C. P. C.)

T	X = .1	.2	.3	.4	.5	.6	.7	.8	.9	1.0	J ave.	$\frac{\partial J}{\partial X}(O,T)$
	$\frac{J_o}{J_i} = 0$											
01	.65804	.85458	.94651	.98440	.99670	.99956	.99997	1.0000	1.0000	1.0000	.90274	8.8879
02	.56240	.75478	.86715	.93285	.96905	.98724	.99537	.99855	.99961	.99990	.86404	7.4741
04	.47762	.65439	.77046	.85050	.90557	.94258	.96653	.98120	.98942	.99306	.80963	6.2804
08	.40390	.56034	.66984	.75192	.81454	.86208	.89734	.92225	.93815	.94589	.73447	5.2763
16	.33676	.46982	.56539	.63924	.69749	.74324	.77831	.80382	.82048	.82872	.63115	4.3861
32	.26381	.36837	.44375	.50224	.54857	.58511	.61322	.63373	.64715	.65379	.49663	3.4344
50	.21292	.29731	.35816	.40539	.44280	.47231	.49501	.51158	.52243	.52779	.40068	2.7718
	$\frac{J_o}{J_i} = .1$											
01	.66192	.85595	.94699	.98453	.99673	.99956	.99997	1.0000	1.0000	1.0000	.90675	7.4586
02	.56792	.75724	.86835	.93343	.96931	.98734	.99541	.99856	.99962	.99990	.86851	6.0722
04	.48505	.65823	.77270	.85185	.90638	.94306	.96680	.98135	.98951	.99311	.81480	4.9098
08	.41353	.56582	.67341	.75436	.81625	.86329	.89821	.92289	.93865	.94633	.74065	3.9415
16	.34902	.47730	.57064	.64317	.70053	.74567	.78031	.80553	.82201	.83015	.63879	3.0939
32	.27991	.37872	.45143	.50833	.55361	.58943	.61703	.63719	.65040	.65694	.55185	2.2046
50	.23289	.31050	.36818	.41352	.44970	.47835	.50046	.51662	.52722	953246	.41281	1.6053
	$\frac{J_o}{J_i} = .2$											
01	.67350	.86006	.94841	.98494	.99682	.99957	.99997	1.0000	1.0000	1.0000	.91213	6.1697
02	.58428	.76466	.87199	.93518	.97010	.98767	.99553	.99860	.99963	.99990	.87527	4.8623
04	.50683	.66971	.77945	.85593	.90684	.94452	.96764	.98182	.98977	.99329	.82352	3.78805
08	.44135	.58211	.68411	.76172	.82141	.86695	.90085	.92484	.94018	.94765	.75235	2.9164
16	.38368	.49929	.58632	.65495	.70970	.75301	.78636	.81070	.82663	.83450	.65471	2.1772
32	.32381	.40859	.47408	.52651	.56876	.60245	.62856	.64769	.66026	.66649	.52863	1.4332
50	.28508	.34770	.39733	.43760	.47031	.49653	.51692	.53191	.54176	.54665	.44066	.9631
	$\frac{J_o}{J_i} = .3$											
01	.69258	.86097	.95081	.98564	.99697	.99959	.99997	1.0000	1.0000	1.0000	.91886	5.0168
02	.61088	.77706	.87812	.93815	.97144	.98822	.99573	.99866	.99964	.99991	.88424	3.8323
04	.54159	.68874	.79079	.86283	.91302	.94699	.96906	.98261	.99021	.99358	.83582	2.8881
08	.48462	.60870	.70193	.77409	.83015	.87318	.90534	.92817	.94279	.94991	.76925	2.1489
16	.43586	.53448	.61204	.67457	.72511	.76542	.79664	.81950	.83450	.84193	.67821	1.6448
32	.38675	.45490	.51049	.55633	.59394	.62430	.64802	.66550	.67702	.68274	.56166	.9605
50	.35638	.40343	.44308	.47643	.50418	.52678	.54456	.55772	.56642	.57075	.48193	.6104
	$\frac{J_o}{J_i} = .4$											
01	.71884	.87674	.95424	.98663	.99718	.99962	.99998	1.0000	1.0000	1.0000	.92690	3.9931
02	.64684	.79447	.88685	.94238	.97336	.98901	.99602	.99875	.99967	.99991	.89533	2.9644
04	.58743	.71510	.80681	.87268	.91901	.95055	.97110	.98375	.99085	.99400	.87710	2.1731
08	.54003	.64478	.72675	.79158	.84260	.88211	.91180	.93297	.94655	.95318	.79090	1.5767
16	.50048	.58097	.64715	.70187	.74681	.78305	.81133	.83215	.84586	.85266	.70850	1.1048
32	.46144	.51392	.55880	.59691	.62883	.65495	.67557	.69087	.70100	.70605	.60406	.6592
50	.43806	.47205	.50203	.52807	.55023	.56859	.58321	.59413	.60139	.60502	.53434	.4010
	$\frac{J_o}{J_i} = .5$											
01	.75186	.88946	.95873	.98793	.99745	.99966	.99998	1.0000	1.0000	1.0000	.93620	3.0899
02	.69109	.81690	.89829	.94798	.97590	.99005	.99640	.99887	.99970	.99992	.90643	2.2373
04	.64238	.74842	.82758	.88561	.92693	.95527	.97382	.98527	.99171	.99456	.86978	1.6055
08	.60458	.68929	.75829	.81421	.85891	.89390	.92038	.93935	.95157	.95754	.81687	1.1452
16	.57363	.63672	.69070	.73649	.77477	.80603	.83065	.84888	.86093	.86693	.77486	.7890
32	.54335	.58235	.61692	.64706	.67280	.69417	.71122	.72397	.73245	.73669	.65463	.4552
50	.52563	.54942	.57105	.52029	.60699	.62104	.63235	.64087	.64657	.64943	.59610	.2655
	$\frac{J_o}{J_i} = .6$											
01	.79115	.90521	.96436	.98956	.99780	.99971	.99998	1.0000	1.0000	1.0000	.94674	2.2970
02	742513	.84429	.91257	.95503	.97911	.99137	.99687	.99902	.99974	.99993	.92341	1.6292
04	.70460	.78821	.85308	.90175	.93692	.96126	.97728	.98721	.99279	.99527	.89103	1.1410
08	.67588	.74105	.79615	.84193	.87918	.90869	.93123	.94747	.95797	.96312	.84677	.8124
16	.65262	.69987	.74164	.77794	.80883	.83440	.85473	.86991	.87998	.88501	.78668	.5530
32	.62990	.65768	.68298	.70550	.72506	.74152	.75479	.76478	.77147	.77482	.71235	.3096
50	.61683	.63281	.64764	.66105	.67287	.68292	.69110	.69730	.70147	.70357	.66572	.1726
	$\frac{J_o}{J_i} = .7$											
01	.83617	.92409	.97121	.99155	.99822	.99976	.99999	1.0000	1.0000	1.0000	.95843	1.6030
02	.80003	.87651	.92981	.96365	.98306	.99299	.99746	.99921	.99979	.99995	.94017	1.1180
04	.77256	.83389	.88325	.92122	.94911	.96862	.98155	.98960	.99414	.99615	.91484	.7818
08	.75215	.79895	.83982	.87461	.90345	.92661	.94448	.95745	.96587	.97001	.88027	.5482
16	.73572	.76885	.79892	.82562	.84874	.86812	.88370	.89541	.90323	.90714	.83347	.3702
32	.71958	.73816	.75540	.77100	.78474	.79643	.80594	.81316	.81801	.82045	.77642	.2008
50	.71046	.72053	.72998	.73864	.74635	.75296	.75838	.76252	.76531	.76672	.74193	.1066
	$\frac{J_o}{J_i} = .8$											
01	.88635	.94615	.97937	.99393	.99872	.99983	.99999	1.0000	1.0000	1.0000	.97125	.9962
02	.86266	.91338	.95008	.97394	.98781	.99495	.99817	.99943	.99985	.99996	.95859	.6863
04	.84504	.88482	.91794	.94407	.96361	.97745	.98671	.99249	.99576	.99722	.94104	.4767
08	.83215	.86196	.88872	.91204	.93172	.94776	.96028	.96944	.97542	.97837	.91713	.3332
16	.82177	.84245	.86160	.87892	.89415	.90709	.91758	.92554	.93088	.93356	.90480	.2232
32	.81149	.82256	.83296	.84249	.85097	.85826	.86423	.86879	.87187	.87342	.84612	.1170
50	.80581	.81144	.81677	.82169	.82610	.82991	.83305	.83546	.83709	.83791	.82368	.0590

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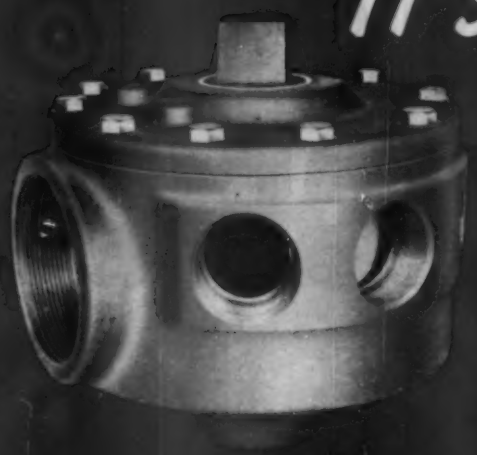

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Brings as many as 7 different Pipe Lines to a central source

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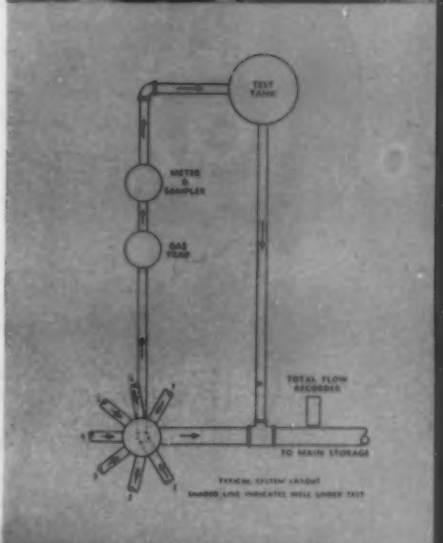

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Greater *service*... more efficient *processes*... these are the benefits to you from this important new partnership!

John B. Merritt, executive vice president of BJ Service, and R. G. Miller, executive vice president of Chemical Process, shake hands and join forces in a powerful new oil well service organization.

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Since 1928, this company has been a pioneer in oil well cementing services, and is recognized as "the company that put quality competition into the business." In addition, it is also recognized as a leader in the field of perforating. *Service* is its middle name.

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Since 1932, this company has been a pioneer in well stimulation service. C.P. developed Permeter service, blocking agents and other services with which the company augments fundamental acidizing and fracturing procedure, plus a personnel which applies more than 2,000 man-years of experience to these operations, add up to complete, progressive, top quality well stimulation service.

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- *Chemical Process stations*

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Stations Throughout the Mid-Continent Area

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Stations Throughout California, Rocky Mountain and Permian Basin Areas

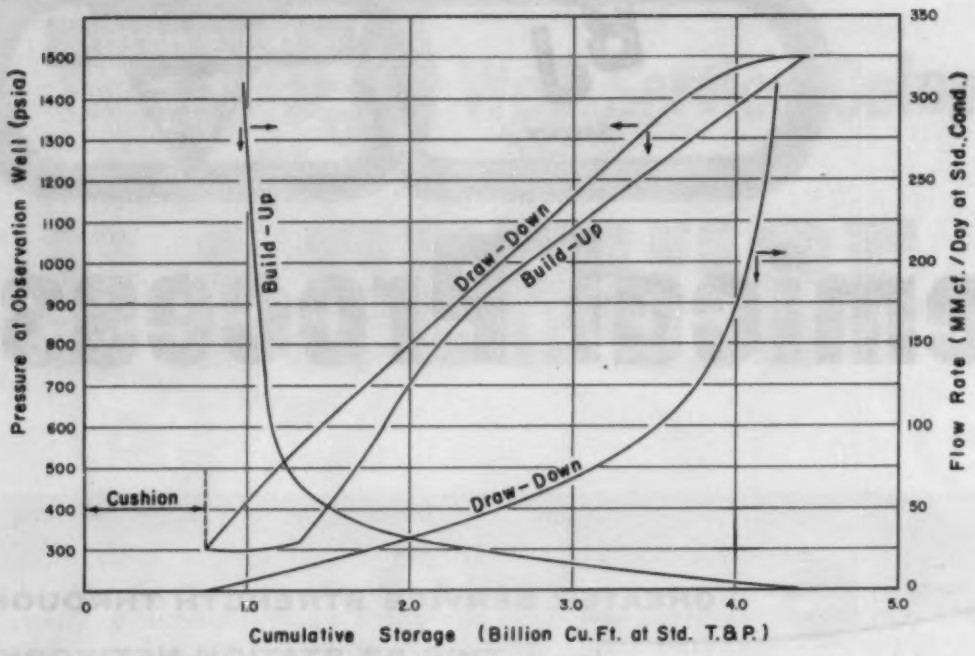

FIG. 7. Observation well pressure and flow rate vs cumulative storage.

is the pressure corresponding to $J_{ave.}$

Pressures obtained by this procedure are bottom-hole pressures and must be corrected if surface pressures are desired.

Results obtained from the above procedure are shown in Fig. 6 and 7. The actual pressure distributions were not plotted since they are of purely academic interest and cannot be observed in the field. Points are included on the graphs that are not listed in the tables.

Cumulative storage and flow rate are shown as functions of time in Fig. 6. These curves would serve as a guide in scheduling reservoir operation when supply and demand can be anticipated; this would be particularly true if more than one reservoir were involved.

Fig. 7 is a plot of observation well pressure and flow rate vs cumulative storage. It is interesting to note that the typical hysteresis loop can be predicted theoretically. These curves also indicate the relation between the observation well pressure and the flow rate.

Investigation of Validity of Results

In order to analyze critically the results obtained in the previous section, either field data or analytical solutions should be available. But, since the reservoir in question is purely hypothetical, no field data exists; and because of the type of governing equation, no analytical solutions exist. The only alternative is to employ a higher order approximation for $f(F/F_i)$ in equation (3) and to assume that it represents the correct results.

Using a second-order approximation for $f(F/F_i)$, equation (3) becomes

$$\frac{\partial}{\partial x}\left\{\left[a_o + a_1\left(\frac{F}{F_i}\right) + a_2\left(\frac{F}{F_i}\right)^2\right]\frac{\partial}{\partial x}\left(\frac{F}{F_i}\right)\right\} = \frac{\phi\mu_a}{KP_c}\frac{\partial}{\partial t}\left(\frac{F}{F_i}\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

which, upon differentiation, reduces to

$$a_o\frac{\partial^2}{\partial x^2}\left(\frac{F}{F_i}\right) + \frac{a_1}{2}\frac{\partial^2}{\partial x^2}\left(\frac{F}{F_i}\right)^2 + \frac{a_2}{3}\frac{\partial^2}{\partial x^2}\left(\frac{F}{F_i}\right)^3 = \frac{\phi\mu_a}{K P_c}\frac{\partial}{\partial t}\left(\frac{F}{F_i}\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

Over the range of interest, it was found that an approximation having $a_o = 0$, $a_1 = 2.70$ and $a_2 = -1.363$ (Fig. 3) will minimize the maximum error; this form drops the first-order term, which reduces the amount of computation at each point in the distance-time mesh. Using this approximation, the dimensionless equation is

$$\frac{\partial^2}{\partial X^2}\left(\frac{F}{F_i}\right)^2 + \frac{2a_2}{3a_1}\frac{\partial^2}{\partial X^2}\left(\frac{F}{F_i}\right)^3 = \frac{\partial}{\partial T'}\left(\frac{F}{F_i}\right) \quad . \quad . \quad . \quad (12)$$

where X and F have their previous forms and $T' = \dfrac{a_1 K P_c}{2\phi\mu_a L^2} t$

The necessary equations for solution of (12) as applied to the example problem are the following:

$$\left(\frac{F}{F_i}\right)_{X,T'+\Delta T'} = \lambda\left[\left(\frac{F}{F_i}\right)^2_{X+\Delta X} + \left(\frac{F}{F_i}\right)^2_{X-\Delta X} - 2\left(\frac{F}{F_i}\right)^2_X\right]_{T'} - .337\lambda\left[\left(\frac{F}{F_i}\right)^3_{X+\Delta X} + \left(\frac{F}{F_i}\right)^3_{X-\Delta X} - 2\left(\frac{F}{F_i}\right)^3_X\right]_{T'} + \left(\frac{F}{F_i}\right)_{X,T'}$$

(for $0 < X < 1$)

. . . . . (13)

$$\left(\frac{F}{F_i}\right)_{X,T'+\Delta T'} = \lambda^2\left[\left(\frac{F}{F_i}\right)^2_{X-\Delta X} - \left(\frac{F}{F_i}\right)^2_X\right]_{T'} - .337\lambda\left[\left(\frac{F}{F_i}\right)^3_{X-\Delta X} - \left(\frac{F}{F_i}\right)^3_X\right]_{T'} + \left(\frac{F}{F_i}\right)_{X,T'}$$

(for $X = 1$)

$$\left(\frac{F}{F_i}\right)_{O,T'} = .173$$

$$\left(\frac{F}{F_i}\right)_{X,O} = 1.0$$

Once again, it is necessary to investigate the errors in this type of solution.

(a) Assuming that the solutions have the same general form as the "linearized" solutions, the truncation errors should be of the same order of magnitude. Consequently, $\Delta X = .10$ and $\Delta T'_{max.} = .0025$ may be assigned.

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TABLE 2.
(C. P. C.)

T	X = .1	.2	.3	.4	.5	.6	.7	.8	.9	1.0	J ave.	$\frac{\partial J}{\partial X}(0,t)$
	$\frac{J_1}{J_0} = 0$											
.01	.62221	.12445	.00129	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.09143	−3.1781*
.02	.74812	.43558	.08391	.00100	.00000	.00000	.00000	.00000	.00000	.00000	.14004	−2.2155
.04	.82941	.63154	.40392	.13500	.00615	.00000	.00000	.00000	.00000	.00000	.21637	−1.5695
.08	.88250	.75183	.60723	.44794	.27309	.08138	.00308	.00000	.00000	.00000	.32086	−1.1020
.16	.91846	.83053	.73596	.63453	.52595	.40987	.28563	.15185	.02699	.00032	.47593	− .7834
.30	.94121	.87912	.81371	.74509	.67350	.59936	.52336	.44413	.37198	.34214	.63242	− .5714
	$\frac{J_1}{J_0} = .1$											
.01	.65520	.24360	.10774	.10016	.10000	.10000	.10000	.10000	.10000	.10000	.18464	−3.1140
.02	.76890	.49527	.21687	.11089	.10050	.10002	.10000	.10000	.10000	.10000	.23195	−2.0984
.04	.84249	.66363	.46674	.26622	.13522	.10368	.10028	.10002	.10000	.10000	.30156	−1.4684
.08	.89121	.77174	.64220	.50428	.36242	.22907	.13824	.10677	.10092	.10012	.39877	−1.0345
.16	.92440	.84347	.75734	.66629	.57088	.47220	.37238	.27585	.19246	.14177	.53384	− .7144
.30	.94649	.89047	.83227	.77243	.71183	.65194	.59506	.54479	.50311	.48472	.68903	− .5226
	$\frac{J_1}{J_0} = .2$											
.01	.69037	.35052	.21520	.20072	.20002	.20000	.20000	.20000	.20000	.20000	.25083	−2.9452
.02	.79109	.55424	.33097	.22345	.20249	.20020	.20001	.20000	.20000	.20000	.32180	−1.0995
.04	.85687	.69799	.53016	.37108	.25885	.21323	.20225	.20032	.20004	.20001	.36853	−1.3526
.08	.90089	.79349	.69732	.56136	.44529	.34139	.26418	.22276	.20663	.20201	.47422	− .9496
.16	.93103	.85781	.78074	.70047	.61808	.53527	.45489	.38161	.32295	.28920	.59568	− .6684
.30	.95268	.90360	.85330	.80254	.75240	.70442	.66064	.62369	.59659	.58216	.73710	− .4644
	$\frac{J_1}{J_0} = .3$											
.01	.72715	.44809	.32193	.30169	.30008	.30000	.30000	.30000	.30000	.30000	.37654	−2.6975
.02	.81456	.61270	.43241	.33390	.30571	.30072	.30007	.30001	.30000	.30000	.41019	−1.7723
.04	.87235	.73385	.59264	.46431	.37108	.32325	.30608	.30134	.30026	.30005	.46717	−1.2222
.08	.91137	.81664	.71785	.61835	.52338	.44022	.37655	.33603	.31519	.30711	.54690	− .8558
.16	.93828	.87336	.80584	.73662	.66705	.59906	.53549	.48030	.43859	.41584	.65452	− .6012
.30	.95916	.91718	.87470	.83251	.79167	.75350	.71960	.69178	.67190	.66151	.78065	− .3977
	$\frac{J_1}{J_0} = .4$											
.01	.76504	.53854	.42677	.40290	.40019	.40001	.40000	.40000	.40000	.40000	.46170	−2.3919
.02	.83911	.67046	.52549	.44025	.40921	.40161	.40022	.40002	.40000	.40000	.49736	−1.5701
.04	.88873	.77071	.65397	.55079	.47452	.43026	.41030	.40303	.40079	.40022	.54744	−1.0790
.08	.92253	.84089	.75727	.67487	.59794	.53135	.47936	.44371	.42288	.41367	.61717	− .7538
.16	.94611	.88999	.83237	.77426	.71705	.66259	.61326	.57195	.54187	.52593	.71087	− .5278
.30	.96563	.93063	.89559	.86127	.82858	.79857	.77243	.75137	.73656	.72890	.82026	− .3406
	$\frac{J_1}{J_0} = .5$											
.01	.80364	.62356	.52908	.50409	.50036	.50002	.50000	.50000	.50000	.50000	.55292	−2.0450
.02	.86454	.72739	.61279	.54217	.51197	.50267	.50048	.50007	.50001	.50000	.58346	−1.3462
.04	.90589	.80824	.71414	.63259	.57154	.53335	.51353	.50484	.50157	.50055	.62618	− .9234
.08	.93429	.86602	.79728	.73079	.66974	.61729	.57584	.54627	.52790	.51928	.68534	− .6443
.16	.95445	.90749	.85992	.81272	.76716	.72475	.68730	.65675	.63503	.62372	.76475	− .4484
.30	.97497	.94986	.92493	.90104	.87841	.85798	.84020	.82598	.81594	.81076	.87061	− .2499
	$\frac{J_1}{J_0} = .6$											
.01	.84267	.70439	.62859	.60496	.60055	.60004	.60000	.60000	.60000	.60000	.64353	−1.6686
.02	.89068	.78348	.69581	.64000	.61332	.60358	.60079	.60014	.60002	.60000	.66856	−1.1038
.04	.92371	.84622	.77322	.71085	.66369	.63267	.61498	.60619	.60236	.60101	.70349	− .7568
.08	.94658	.89186	.83764	.78604	.73929	.69934	.66754	.64437	.62952	.62235	.75160	− .5277
.16	.96317	.92562	.88807	.85138	.81650	.78482	.75732	.73531	.71991	.71197	.81622	− .3647
.30	.97810	.95613	.93456	.91389	.89467	.87747	.86256	.85136	.84341	.83935	.88072	− .2182
	$\frac{J_1}{J_0} = .7$											
.01	.88194	.78190	.72528	.70521	.70070	.70006	.70000	.70000	.70000	.70000	.73353	−1.2707
.02	.91740	.83875	.77551	.73426	.71287	.70401	.70104	.70022	.70004	.70001	.75273	− .8458
.04	.94210	.88450	.83128	.78630	.75200	.72860	.71436	.70661	.70288	.70143	.77946	− .5805
.08	.95934	.91828	.87821	.84062	.80092	.77827	.75538	.73850	.72751	.72213	.81610	− .4046
.16	.97218	.94412	.91642	.88975	.84484	.84246	.82338	.80833	.79791	.79259	.86536	− .2770
.30	.98397	.96800	.95245	.93768	.92408	.91201	.90184	.89390	.88844	.88567	.92040	− .1606
	$\frac{J_0}{J_1} = .8$											
.01	.92131	.85672	.81928	.80459	.80073	.80007	.80000	.80000	.80000	.80000	.79627	− .8574
.02	.94458	.89324	.85250	.82541	.81049	.80367	.80108	.80027	.80005	.80001	.83600	− .5746
.04	.96098	.92293	.88838	.85942	.83717	.82157	.81160	.80581	.80281	.80157	.85416	− .3950
.08	.97253	.94518	.91887	.89449	.87285	.85452	.83987	.82999	.82185	.81832	.87895	− .2753
.16	.98138	.96280	.94467	.92745	.91158	.89752	.88567	.87643	.87009	.86686	.91229	− .1864
.30	.98958	.97926	.96929	.95989	.95130	.94374	.3742	.93250	.92914	.92744	.94884	− .1057

*Negative sign indicates flow into reservoir.

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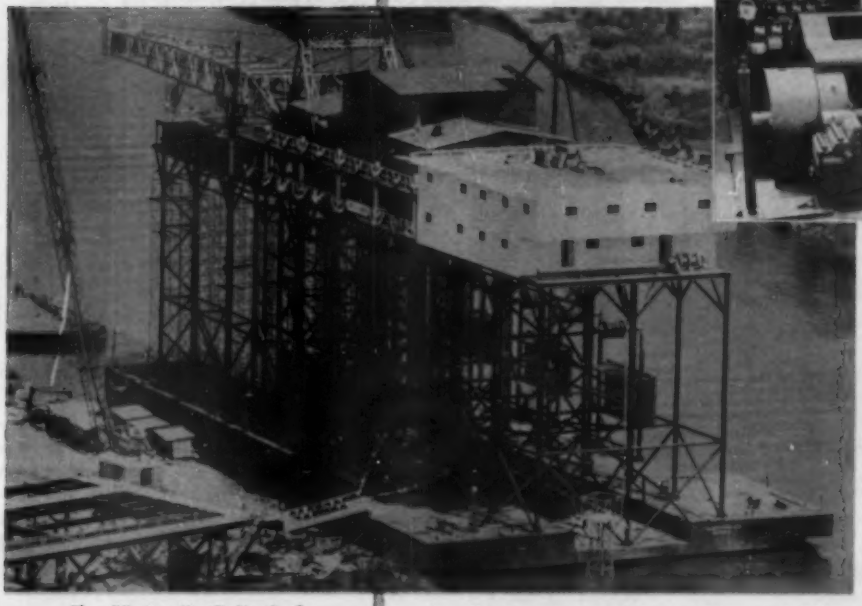

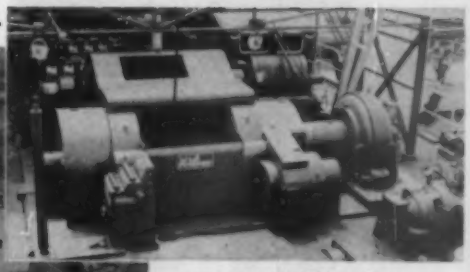

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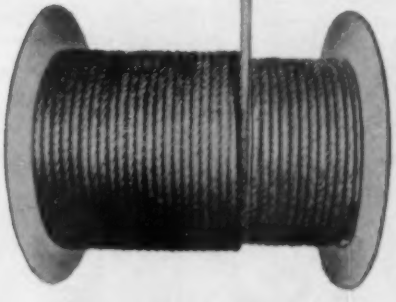

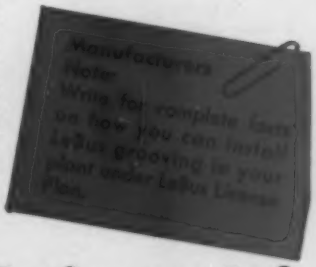

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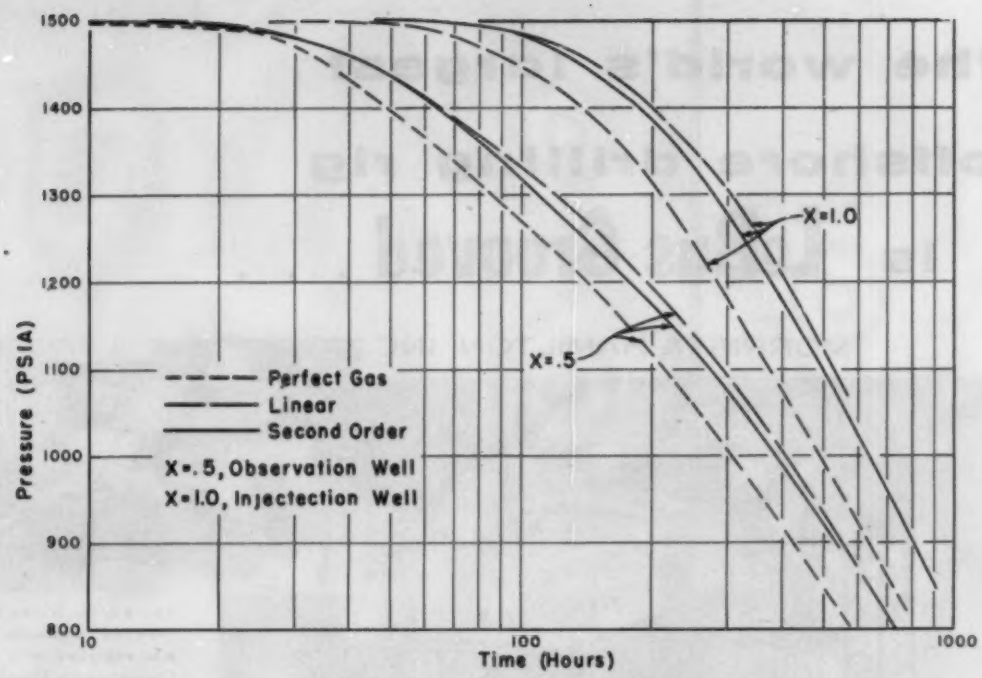

FIG. 8. Pressure vs time at a point.

(b) To determine the critical value of λ, analysis of error amplification is necessary. The method of O'Brien, Hyman and Kaplan[10] is used.

Writing the expressions for $\left(\frac{F}{F_i}\right)_{X,T'+\Delta T'}$ and for $\left(\frac{F}{F_i}+e\right)_{X,T'+\Delta T'}$ in the form of equation (12) subtracting one from the other, and ignoring e^2 and higher order terms, leads to a linear equation for the error, e, which may be solved harmonically. This results in an expression for the error amplification at a point, between successive time-steps, that may be expressed as follows:

$$A_X = 1 - 8\lambda\left(\frac{F}{F_i}\right)_{T'}\left[1 - \frac{a_2}{a_1}\left(\frac{F}{F_i}\right)_{T'}\right]\left(\sin^2\frac{m_X\Delta X}{2}\right) \quad . \quad . \quad (14)$$

where $\left(\frac{F}{F_i}\right)_{T'}$ = average value in the T' time-step.

To prevent error growth, the condition, $|A_X| < 1$ must be fulfilled. Since the maximum value of $\left(\frac{F}{F_i}\right)_{T'}$, is 1.0 and the maximum value of $\sin^2\frac{m_X\Delta X}{2}$ is also 1.0, the maximum value of λ is given by

$$\lambda = \frac{1}{4\left(1 + \frac{a_2}{a_1}\right)} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (15)$$

When $a_1 = 2.700$ and $a_2 = -1.363$, the maximum value of the ratio is found to be .505 for computational stability. With ΔX of .10, this would allow $\Delta T'$ to be .00505; however, it was observed in the solution of the linear case that a $\Delta T'$ of .00125 is necessary to obtain accurate results in the early history. Consequently, the ratio should have the value of .125 (at least until T' equals .10). The four-point, predictive form of the difference equation, subject to the specified boundary conditions, given in equation (13) may now be solved.

Through the courtesy of the Programming Research Group of Remington Rand, time was made available on the Univac System installed in Philadelphia, Pennsylvania. The equations were pseudo-coded for the A-2 compiler, which transformed the instructions into the machine code. The equations were then solved using 11-digit floating decimal arithmetic.

Some of the results obtained are listed in Table 3 together with the average $\frac{F}{F_i}$ values and the dimensionless gradient at X = 0.

Fig. 8, 9 and 10 show a comparison of the transformed results with those obtained from the "linearized" solution and from the perfect gas solution. The perfect gas solutions were obtained by letting $Z = 1$; $\mu = \mu_{average}$, $a = 0$ and $b = \frac{P_i}{P_e}$, which made $F = \frac{P}{P_i}$; the num-

TABLE 3.
(Univac)

$\frac{F}{F_i} = .173$

T'	X = .1	.2	.3	.4	.5	.6	.7	.8	.9	1.0	(F/Fi) ave.	$\frac{\partial(F/F_i)}{\partial X}$
.005	.77694	.95840	.99600	.99985	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000	.93927	8.1967
.01	.68105	.89150	.97322	.99539	.99946	.99996	1.00000	1.00000	1.00000	1.00000	.91862	6.1636
.02	.58703	.79519	.91220	.96857	.99072	.99774	.99955	.99993	.99999	1.00000	.88836	5.2146
.04	.50299	.68968	.81685	.90019	.95046	.97774	.99098	.99670	.99889	.99959	.84464	4.0604
.08	.43166	.59076	.70958	.80016	.86781	.91638	.94945	.97052	.98266	.98813	.78261	3.1294
.16	.37033	.50030	.62224	.68551	.75382	.80899	.85210	.88384	.90471	.91506	.69250	2.3551
.24	.34201	.45684	.54789	.62314	.68572	.73706	.77782	.80830	.82861	.83876	.63293	2.0060
.32	.31997	.42231	.50376	.57118	.62731	.67339	.71002	.73743	.75570	.76485	.58035	1.7370
.40	.30203	.39389	.46718	.52779	.57185	.61942	.65216	.67661	.69289	.70103	.53587	1.5211

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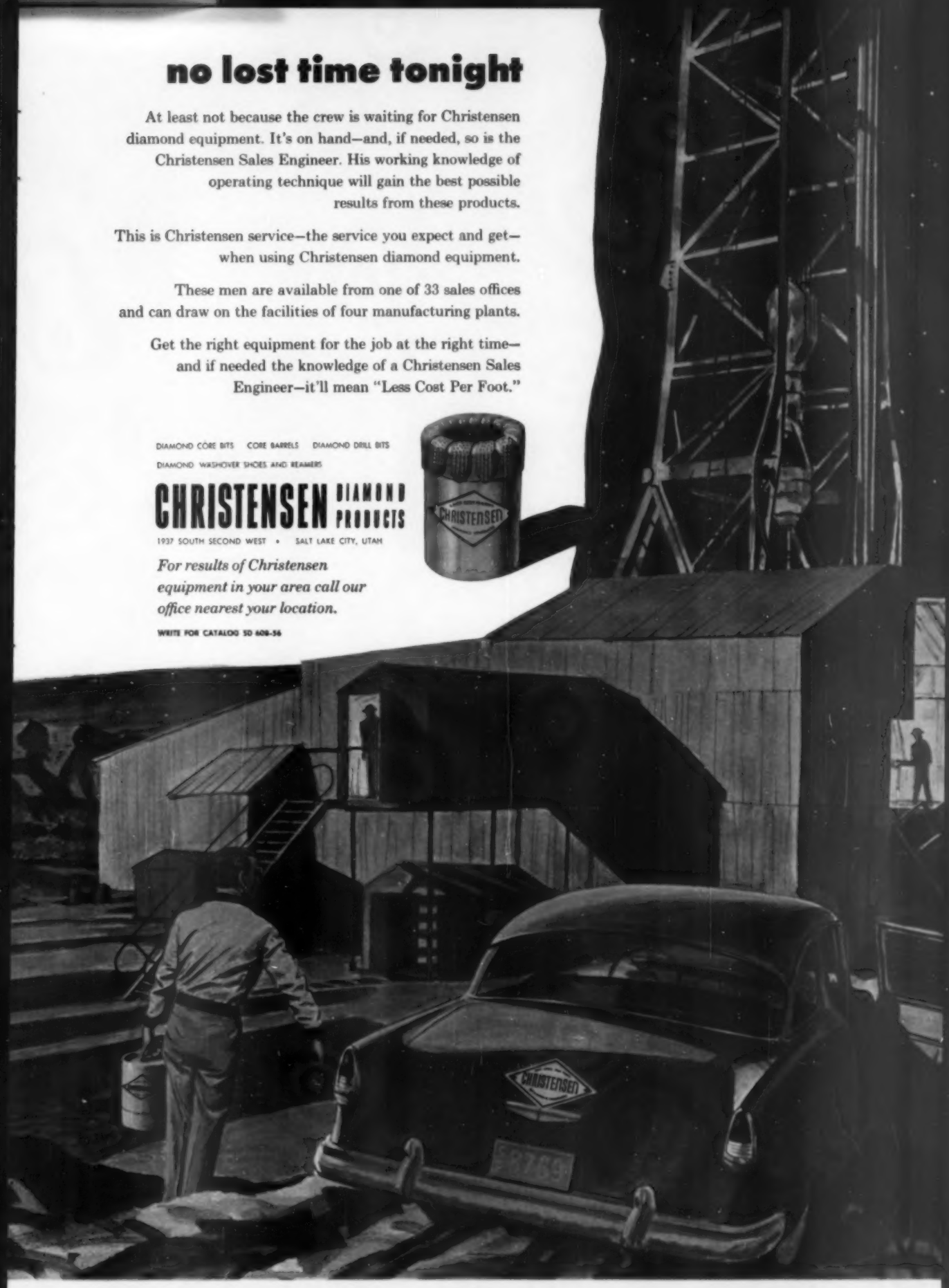

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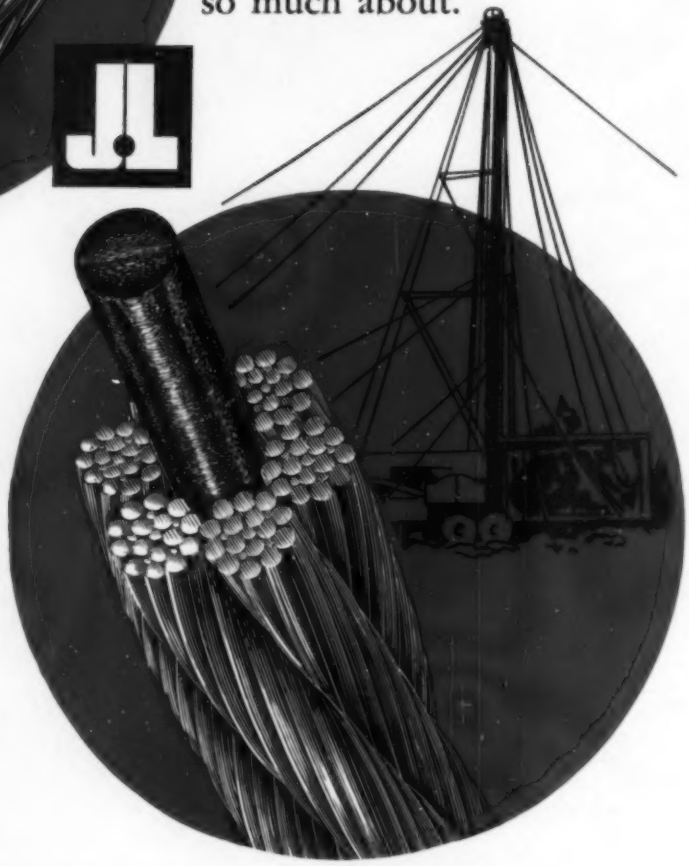

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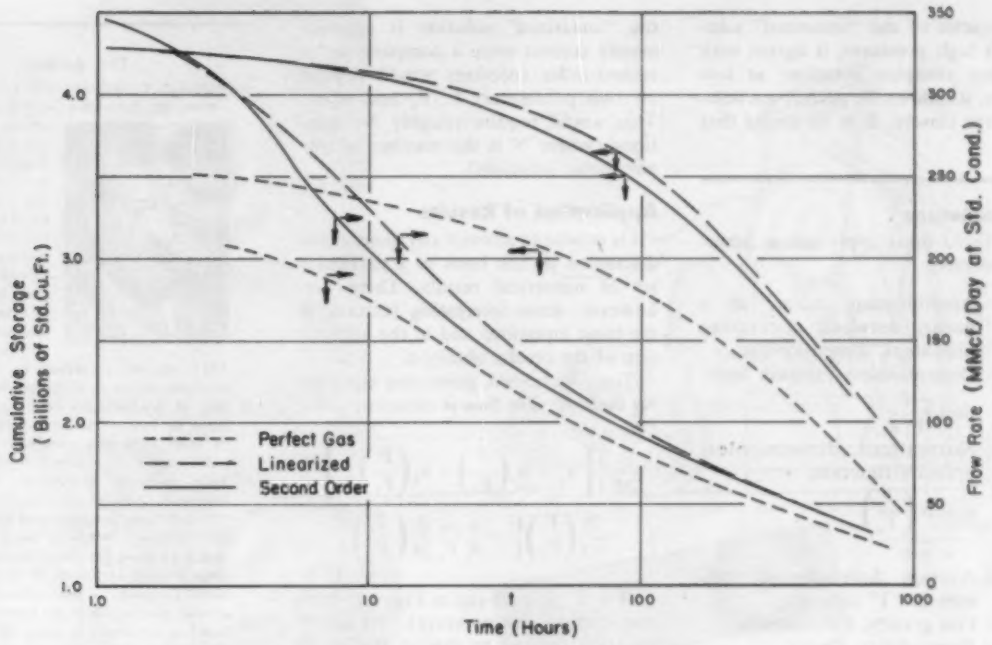


FIG. 9. Cumulative storage and flow history.

erical values were taken from $\frac{J_e}{J_i} = .2$ in Table 1.

Fig. 8 shows the change in pressure with time at both the observation well and the injection wells. This plot indicates a reasonably good fit between the "linearized" solution and the second-order solution over the interval investigated. The regions of greatest deviation occur at roughly the same pressure points at which there is the largest variance between the curve in Fig. 3. The perfect gas solution has the same general form, but it is shifted on the time axis.

Relations between time and flow rate and time and cumulative storage are shown in Fig. 9. The validity of the "linearized" solution is again exhibited. In this case, the perfect gas results are shifted vertically because of neglecting Z; the time-lead is not as noticeable as in the previous graph.

Fig. 10 illustrates the behavior of the observation well pressure as a function of cumulative storage. The complete hysteresis loops are of the same shape, but they differ in their orientation. This plot shows the compromis-

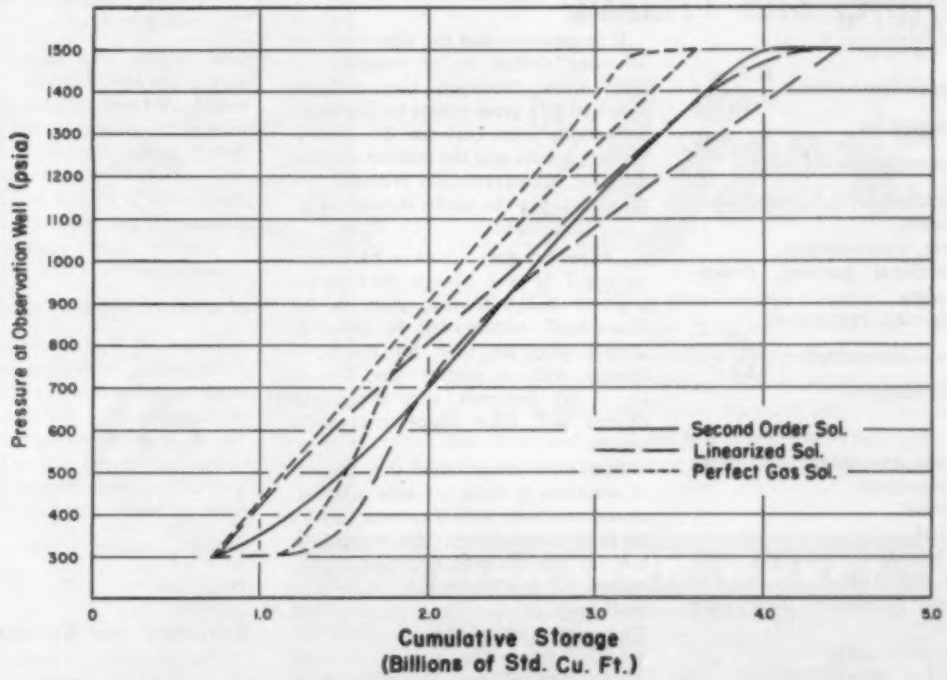


FIG. 10. Observation well pressure as a function of cumulative storage.

ing character of the "linearized" solution. At high pressures, it agrees with the more complex solution; at low pressure, it follows the perfect gas solution more closely. It is fortunate that the "linearized" solution is approximately correct since a complete set of second-order solutions would depend on two parameter, F_o/F_i and a_2/a_1. This would require roughly N^2 solutions (where N is the number of one parameter solutions).

Nomenclature

The listed units apply unless otherwise specified.

A_X = Amplification factor, at a point, between successive time-steps, dimensionless

F = Dimensionless pressure function, $\frac{P}{P_c Z}$

J = Normalized, dimensionless pressure function, $\frac{a + b\left(\frac{F}{F_i}\right)}{a + b}$

J_T = Average dimensionless pressure in "T" time-step

G = Gas gravity, dimensionless

K = Permeability, Darcy

L = Length, cm.

P = Pressure, dynes/cm²

P_R = Pseudoreduced pressure, dimensionless, $\frac{P}{P_c}$

R = Temperature, °Rankine

R_R = Pseudoreduced temperature, $\frac{R}{R_c}$

S_w = Water saturation, per cent of pore volume

t = time, seconds

T = dimensionless time, $\frac{K P_c (a + b)}{2 \phi \mu_a L^2} t$

T' = Dimensionless time, $\frac{K P_c a_1}{2 \phi \mu_a L^2} t$

x = distance, cm.

X = Dimensionless distance, $\frac{x}{L}$

Z = Compressibility factor, dimensionless

e = error, dimensionless

ϕ = Fractional porosity, dimensionless

μ = Viscosity, centipoises

λ = Constant multiplier, $\frac{\Delta T}{(\Delta X)^2}$, dimensionless

Subscripts:

a = at one atmosphere and flowing temperature

c = critical

i = initial

s = at standard conditions, 14.65 psi and 60 F

T = Time coordinate, dimensionless

X = distance coordinate (0, 1, ... 1.0), dimensionless

Application of Results

It is unwise to attempt any generalized discussion on the basis of a particular set of numerical results. There are, however, some interesting features in the basic equations and in the application of the results obtained.

The generalized, governing equation for compressible flow is equation (10); i.e.,

$$\frac{\partial}{\partial x}\left\{\left[a_o + a_1\left(\frac{F}{F_i}\right) + a_2\left(\frac{F}{F_i}\right)^2\right] \frac{\partial}{\partial x}\left(\frac{F}{F_i}\right)\right\} = \frac{\phi \mu_a}{K P_c} \frac{\partial}{\partial t}\left(\frac{F}{F_i}\right) \quad \ldots\ldots\ldots (10)$$

If $a_1 = a_2 = 0$ (as in Fig. 2 at high temperature and pressure), the above equation reduces to that of the linear equation for flow of a slightly compressible liquid or heat/mass transfer with constant transfer coefficients. If $a_2 = 0$, the equation is of the type principally considered in this paper (the special case where $a_o = 0$ and $a_1 = \frac{P_i}{P_c}$ is the perfect gas case); this equation also applies where heat or mass transfer coefficients are linear functions of the dependent variables. If $a_o = 0$, the equation becomes the second-order case, which was assumed to be the correct solution.

It is apparent that the dimensionless solutions should be of roughly the same form; however, they will be modified to a great extent by the transformations used between the dimensionless results and the real values. For example, transformation accounts for the time-lag in the results shown in Fig. 8; $\frac{t\ (\text{linearized})}{t\ (\text{perfect gas})} = \frac{P_i \mu_a}{(a + b) P_c \mu_{ave.}}$ for any T. If $(a + b) \rightarrow 0$, the time for a given change to take place in the "linearized" system will be infinitely greater than the time for the same change with a perfect gas; but if $(a + b)$ becomes very large, the change will take place extremely rapidly.

It must be emphasized that this set of solutions is valid for only a linear, closed reservoir with a constant outlet pressure and uniform initial pressure. For any other boundary or initial conditions, or a different flow pattern, a new set of solutions must be obtained. These presented solutions may be used, however, where the terminal pressure is a function of time subject to certain restrictions. These conditions are:

(a) The pressure must remain constant throughout a given operating interval.

(b) The reservoir must be shut-in between pressure changes for a period of time at least as long as the previous operating period (this has been partially verified by additional computation, but it is still a rather weak criterion).

This implies that the average pressure at the end of the first period is the initial, uniform pressure at the beginning of the second period. The greatest defect in this method is that it gives only one-half of the history of the reservoir; the shut-in build up of pressure is not obtained. To complete the description of the reservoir behavior, it would be necessary to obtain a set of solutions where $P_i = f(X)$ and $\frac{\partial P}{\partial X} = O$ at both $X = O$ and $X = 1.0$.

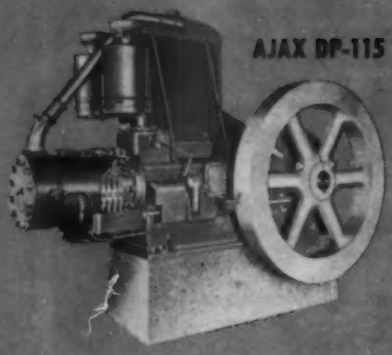
Regarding interpolation, a cursory study indicates that numerical accuracy of the order of 1 per cent may be obtained from the data given. In the X-direction, interpolation is linear; in the T-direction, logarithmic interpolation must be used. When interpolating between $\frac{J_o}{J_i}$ values, a linear approach is employed.

Summary and Conclusions

The following conclusions were drawn from an analysis of the numerical results:

The Author

Joseph E. Warren is a graduate assistant at Pennsylvania State College while completing his PhD degree in petroleum engineering. He attended Purdue and Marquette Universities and received his BS in petroleum engineering from the University of Pittsburgh in 1951. He was employed as a research engineer in the reservoir mechanics section of Stanolind's research department at Tulsa, Oklahoma. He returned to Penn State and obtained his MS in petroleum engineering in 1954, and held research fellowships from the American Gas Association, Stanolind Oil and Gas Company and Continental Oil Company. While at Penn State, he was employed for three years as part-time project engineer for J. I. Thompson & Company, Washington, D. C., and served as consultant on reservoir engineering problems in association with Dr. John C. Calhoun.



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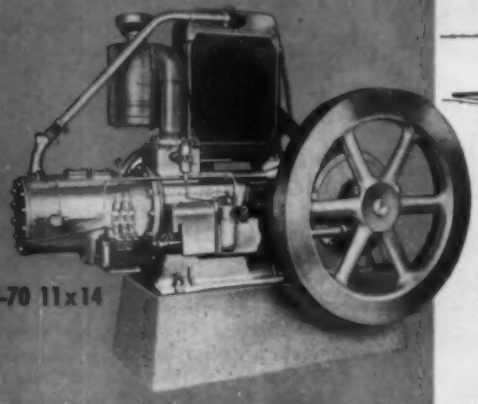

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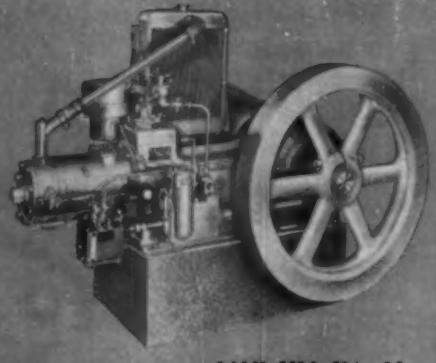

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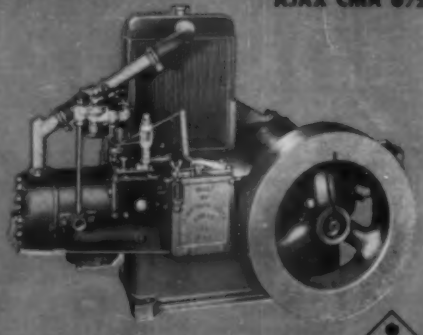

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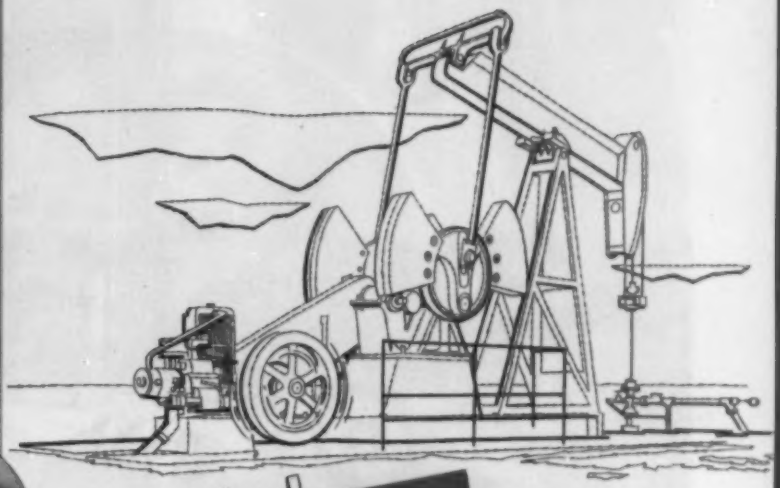

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(1) Behavior of gas-storage reservoirs, of the type considered, can be predicted with a reasonable degree of accuracy by the linearized method.

(2) The perfect gas type of solution is not valid in cases where compressibility and viscosity vary widely. Numerical solutions presented apply to perfect gases if proper substitutions are made.

(3) The expanded form of the governing equation can be solved numerically. It is useful in those cases in which a linear approximation is impossible, but is not practical as a general solution since it contains two parameters.

(4) A method for handling problems involving discontinuous reservoir operations is presented. Further work will be necessary before this method can be considered complete.

Acknowledgment

Grateful acknowledgement is made for support given this project by the American Gas Association, Socony-Mobil Oil Company, Magnolia Petroleum Company, and the Remington Rand Division of the Sperry Rand Corporation. Thanks are also extended to the Mineral Industries Experiment Station of the Pennsylvania State University for permission to publish this paper.

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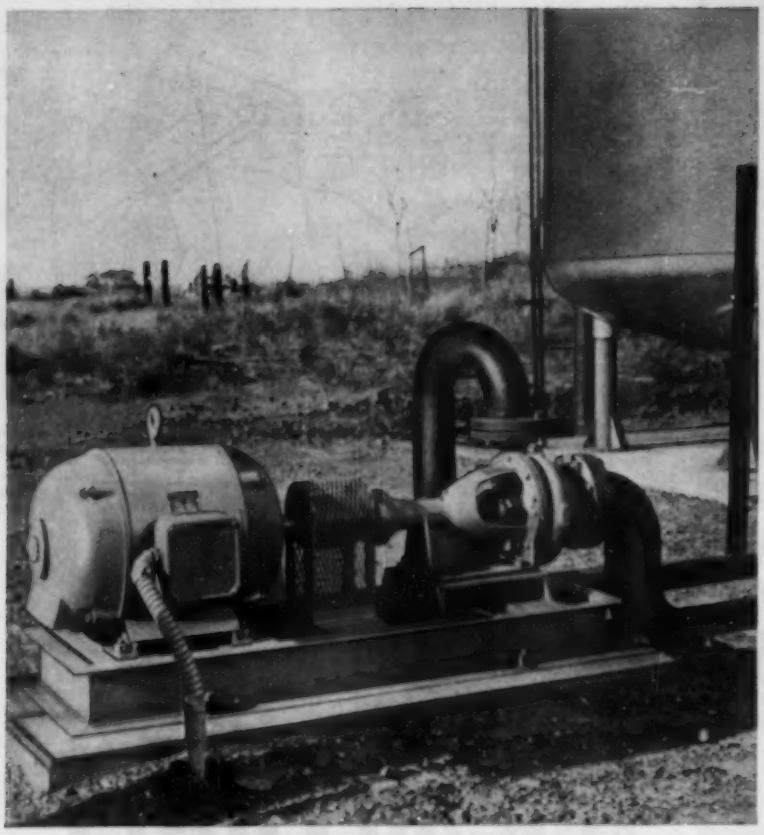

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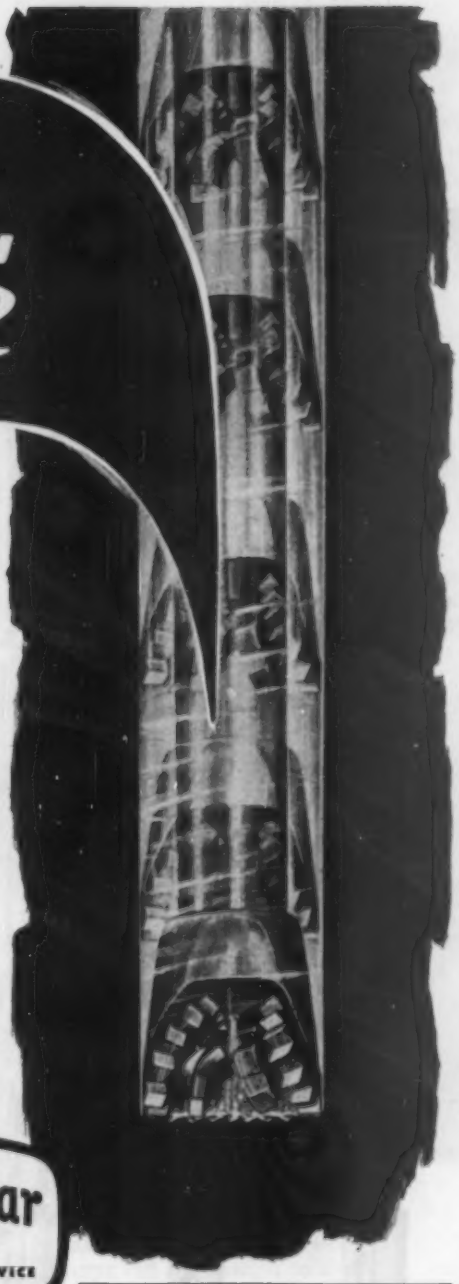

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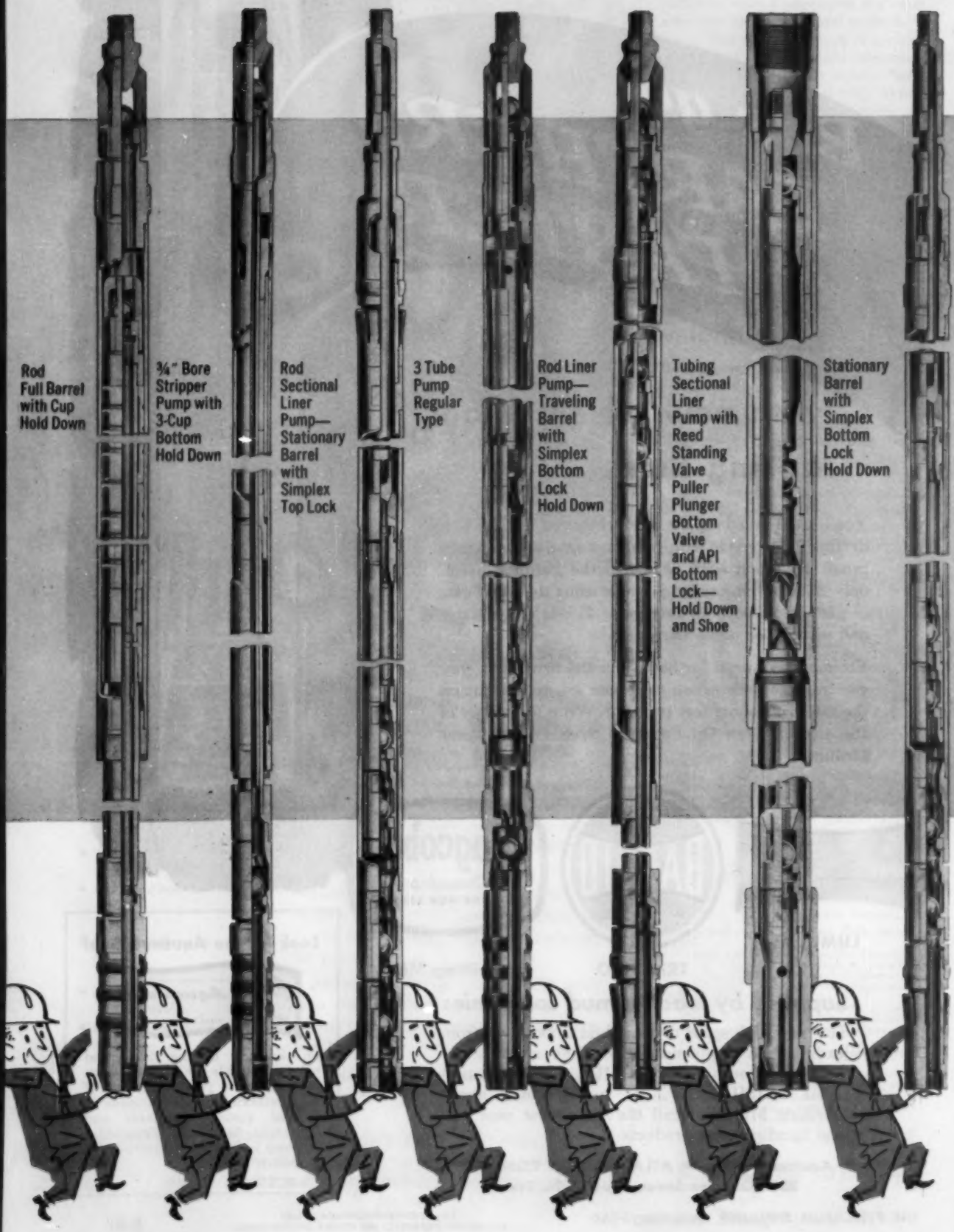
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AAODC Ponders Low Reserves, High Costs, Industry Harmony, Personnel Deficits

Petroleum engineers Abernathy, Teague picked to lead drillers in 1957

INDUSTRY'S problems were met "head on" by drillers attending the convention of the American Association of Oilwell Drilling Contractors. Some 1100 contractors registered at the organization's sixteenth annual meeting in Fort Worth, Texas, October 7-9.

Sincere, realistic optimism prevailed throughout the sessions, although top industry and government leaders challenged the group with problems related to currently sinking U. S. oil reserves, the aspect of still higher costs, and of lack of organized teamwork among segments of the oil industry.

E. O. Thompson Sees Reserves Slipping

AAODC conventioners heard Lt. General Ernest O. Thompson of the Texas Railroad Commission declare that "the oil center of the world has shifted from our Gulf Coast to the Persian Gulf." The veteran Commissioner, speaking at the first general session, urged the group to make a more intense search for new oil fields in the United States to keep the country's reserves high.

"In the last 10 years this country has gone from a net exporter to a net importer of oil," Thompson said. "Most of this imported oil is coming from the Middle East fields near the Persian Gulf. Reserves of these fields were estimated at 230,000,000 bbl at the end of 1954. Impressive discoveries have been made since that time," he said.

The Railroad Commission member noted that last year, in spite of increased and deeper drilling, this country imported oil and oil products of over 1000 bbl a day to make up the difference between production and consumption. Thompson indicated that we "used up our production five times as fast as we discovered new reserves." Citing Texas as an example, he said that this state's reserves declined 48,501,000 bbl last year, whereas production totaled 1,022,339,000 bbl.

"Analyzing the figures for last year, it will be quickly seen that Texas produced and sold her oil last year at a rate greater than six times the rate of discoveries in new fields and in new pools in the old fields," said Thompson.

Dale Mount Says Competition "Healthy"

E. Dale Mount, retiring AAODC president, indicated that the drilling industry was prepared to meet the demand for more drilling to find needed reserves. Mount, of Harry Bass Drilling Company, Dallas, Texas, said that advancements brought about by the intense competition faced by U. S. drillers had permitted this progress. "We contractors know that alertness and advanced techniques are necessary to our survival and that only by banding ourselves together in an association organized such as ours can maximum progress for all be achieved."

Mount defended the competition that exists. "Competition in the interest of serving our customers is a healthy thing, and based on the right attitude, it will do wonders toward keeping us progressive. We in our business, to be successful, must be competent to balance our costs, drilling efficiencies, advance techniques, and skill, against the know-how of our competitors within the area of available operations, and above all, produce profits."

A. W. Thompson Talks Teamwork

Texas independent producer and drilling contractor A. W. Thompson pointed up the need for industry cooperation in his address before the convention in its closing day session. Thompson, head of A. W. Thompson, Inc., Houston, Texas, explained the benefits of working closer with other organizations within the oil industry in his speech, "API-AAODC Teamwork — Key to Greater Progress." Thompson is vice president of production for the American Petroleum Institute. He cited that his experience with the many API committees and study groups has

New officers of the American Association of Oilwell Drilling Contractors for the coming year are president, Jack Abernathy, Big Chief Drilling Company, (right), and J. U. Teague, Columbia Drilling Company, national vice president. Both are graduate petroleum engineers.

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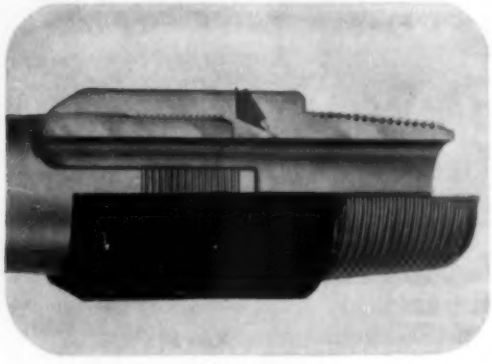

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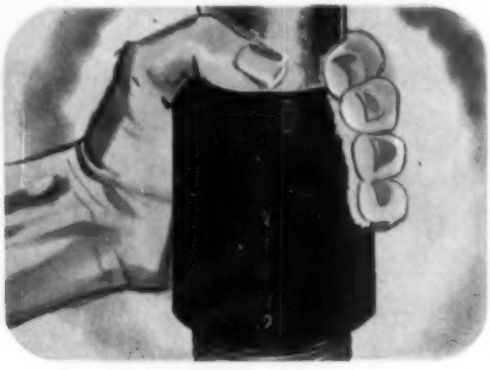

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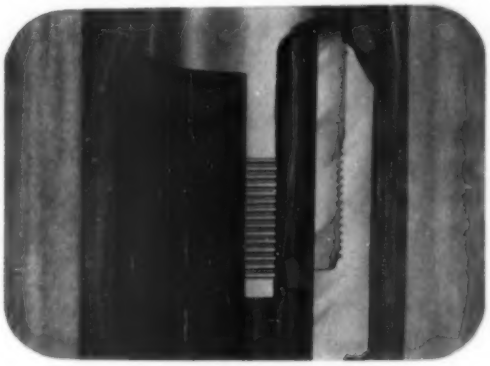

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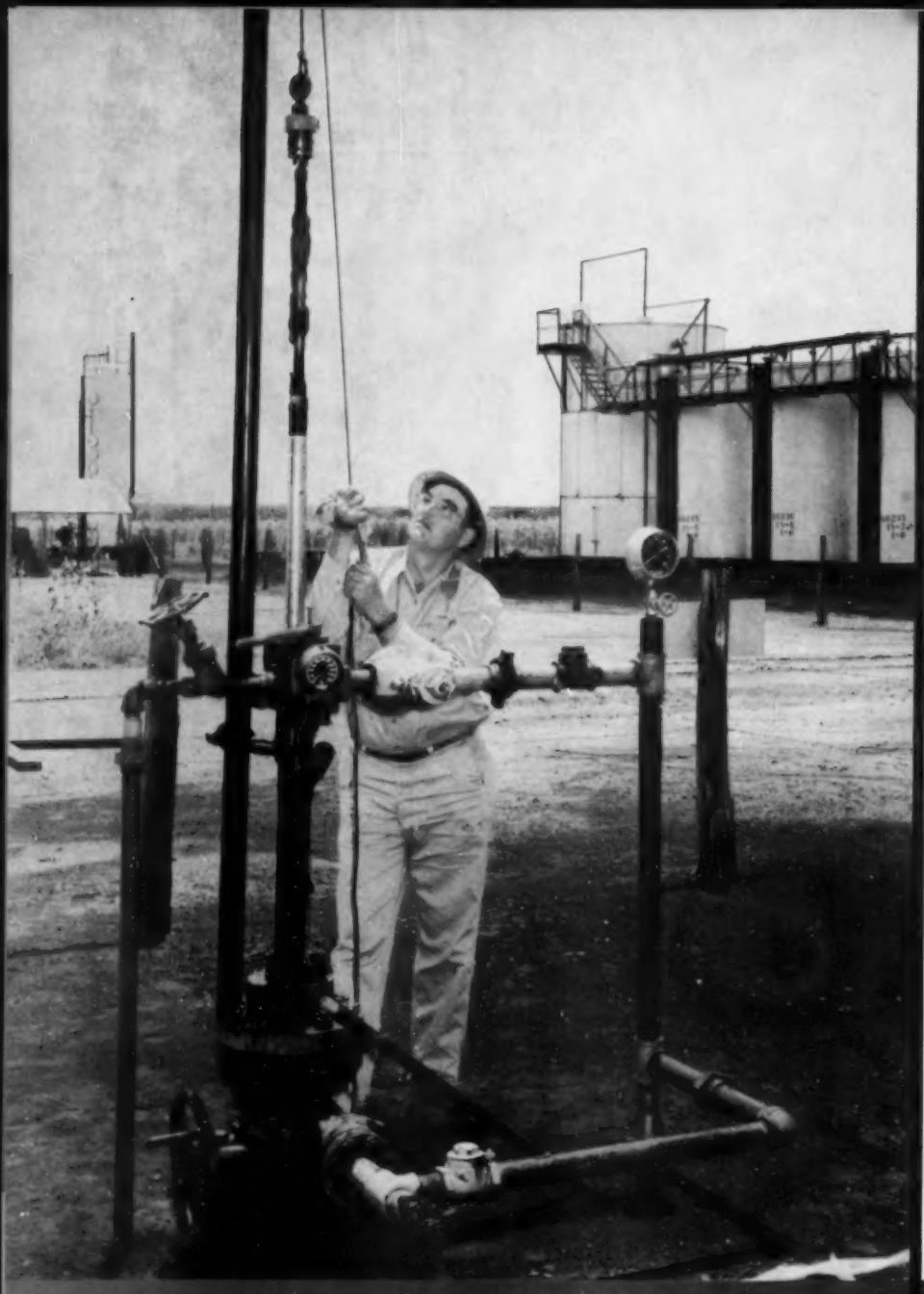

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been "the source of most of my enlightenment. This experience made me realize the untold dollars and cents benefits that operators reap through active participation in these API efforts, and has made me wonder why contractors do not avail themselves of the same opportunity."

Thompson pointed out a series of discouraging statistics about AAODC member participation.

"The drilling contractor is not in competition with any of the API groups. Instead, you are deriving the benefit of their activities.

"Even more important, the drilling industry can be a lot brighter if two teams, rather than one, are working together to develop new and better ideas. We need to share our experience with the API not only to avoid duplication in committee work, but to gain maximum results from efforts that both AAODC and API have been putting forth to solve drilling problems. This in itself should be enough to insure all-out cooperation on our part."

Wood Stresses Industry Harmony

Robert L. Wood, president of Indedendent Petroleum Association of America, Midland, Texas, as well as an AAODC member, also called for a closer link between the domestic oil producers and the drilling contractors.

Wood hit at high crude oil import ratios, stating that U. S. drillers could be and should be drilling more wells. "Two problems stand in the way of more drilling," says Wood. "These are inadequate crude oil prices and excessive imports of foreign crude."

"Correction of these two problems would immediately throw a lot of business your way, because we could — and would — drill thousands of additional wells each year.

"Looking at the over-all picture now, we see that excessive imports and inadequate prices combined cost the domestic producers over 1½ billion dollars, kept the drillers from putting down 11,000 wells, and denied our country tremendous reserves of crude oil and natural gas.

"And we *need* to drill those additional wells."

Burgess Strikes Inflation Fears

W. Randolph Burgess, Undersecretary of the Treasury, addressed the group at the closing banquet. Burgess stressed the need for continued monetary security in the U. S. to sustain the peacetime prosperity that now exists. "This country is not accustomed to peacetime prosperity. We have been through 20 years of depression and wars, both hot and cold. There have been only snatches of peacetime prosperity in between," he declared.

Burgess then explained how this period of high prosperity had been made possible. "All of our present productive activity takes money — more than ever before in peacetime. How shall we find the money to finance this activity without inflation — without, in effect, printing money?"

"Fortunately," the former American Bankers Association president answered himself, "the people of the United States have the habit of saving money. Each year they save 6 to 8 per cent of their income. Business also saves to pay for expansion almost half of what it earns."

Annual Awards Presented

Before the opening day gathering two drilling contractors were presented traditional AAODC annual awards. President's award for leadership in the drilling industry were given to Don Slape, Don Slape Drilling Company, Olney, Illinois. Winner of the special award for service was Baker R. Littlefield, The Power Rig Drilling Company, Lafayette, Louisiana.

1957 Officers Elected

Jack A. Abernathy, active in AAODC work for 12 years, was elected president of the organization for 1957. Abernathy, Big Chief Drilling Company, Oklahoma City, Oklahoma, follows in the step of his "boss," William T. Payne, a former AAODC president.

Abernathy served as vice president of the Central Mid-Continent area of AAODC in 1955-56; he was chairman of the research and education committee. He twice has headed the Central Oklahoma chapter, and has served as a member of the publications and rotary drilling committees. He is now a member of the national committee for drilling practices of the API, and in the past has served as chairman, vice chairman and secretary-treasurer on the committee for standardization of rotary drilling equipment of the Mid-Continent district of API. He is now the oil industry member of the Oklahoma state board for registration of professional engineers, and is chairman of the oil and gas division of the Oklahoma City Chamber of Commerce. He is a petroleum engineering graduate from the University of Oklahoma.

J. U. Teague, president of Columbia Drilling Company, Houston, Texas, was elected national vice president. He has served three times as chairman of the rotary drilling committee, chairman of the Houston regional chapter, vice president of the Gulf Coast area, and a member of the board. He has been active in AAODC work for about 10 years.

Regional Officers Named

Regional vice presidents elected are: M. M. Brantly, of Brantly Drilling Company, Midland, for New Mexico and West Texas; Don Slape, Don Slape Drilling Company, Olney, Illinois, for Illinois, Michigan, Indiana, and Kentucky; Earle C. Hellums, of Gracey-Hellums Corporation, Houston, for the Gulf Coast; Frank E. Frawley, of Frank Frawley Drilling Company, Tulsa, for the Central Mid-Continent area; Will I. Lewis, Jr., of Will I. Lewis Drilling Company, Denver, for the Rocky Mountains; Herbert Woolf, of Woolf & McGee, Tyler, for the Cretaceous and Tertiary Basins; J. D. Huffaker, of F-W-A Drilling Company, Wichita Falls, for North and West Central Texas; and R. C. Sharp, of Drilling & Exploration Company, Inc., Los Angeles, for California.

D. B. Ferguson, Ferguson Drilling Company, Oklahoma City, was elected vice president of the cable tools division, and W. C. Fatjo, of W. C. Fatjo Drilling Company, Tyler, is now vice president of the well servicing division. W. L. McClusky was re-elected secretary-treasurer; Brad Mills, executive vice president, and Marion S. Church, general council.

Abernathy Seeks Trained Personnel

Incoming President Abernathy told the group, speaking in the closing sessions of the convention, that "the main problem facing the industry is finding qualified personnel since the industry has changed from catch-as-catch-can to a technical and complicated business in the last decade." He also challenged the contractors to do their part in countering the marked increase in foreign reserves by finding "as many domestic reserves as fast as possible."

Mount Sets Pace for Drillers

Attitude of the drillers attending the Fort Worth convention was summed up in the words of 1956 President Dale Mount, who well expressed the position of the contractor in today's economy.

"We are in an era of progress and prosperity such as no nation in the world, including our own, has ever known before.

"It is our responsibility to drill the wells to keep our country supplied with petroleum products. By banding together in an association such as ours we can more effectively handle our labor, materials and techniques. We can join with other segments of the oil industry in maintaining free and private enterprise in our country, and we can present a united front in tackling the many problems peculiar to our business." ★ ★ ★

STANDARD LAYOUTS For Oil Field Pump Controls

Standard systems have been developed to control pump discharge rates and pressures in oil field applications. Typical applications are presented here to aid engineers in selecting instruments and equipment

Herbert S. Kindler
Black, Sivalls & Bryson, Inc.
Kansas City, Missouri

IN a large number of field operations it is desirable to regulate the flow of fluids or the pressures in the system. This is of considerable importance in glycol units, desulfurizers, oil heaters, and other units where circulated fluids must be closely regulated. As a result of the extensive use of such equipment in the field, certain more or less standard types of installations have been developed.

A number of pump control systems have been presented in the following pages to assist the petroleum engineer in determining the proper type of system to use and aid in the selection of instrumentation and control requirements. Applications include both centrifugal and reciprocating pumps and are based upon conditions frequently encountered in oil field applications.

Constant Speed Motor Driven Centrifugal Pumps

Typical applications utilizing centrifugal pumps include: Boosting suction pressure of reciprocating pumps on both amine and glycol to absorber services; cooling water circulation; amine transfer and water make-up in desulfurizers, and oil transfer in portable oil heaters. The pump consists essentially of an impeller that rotates inside the pump casing. In operation, liquid enters the impeller axially and centrifugal force produces the flow. The rate of flow is best controlled by throttling on the discharge side of the pump.

Throttling the discharge alters the flow in accordance with the head-capacity curve of the particular pump used.

Characteristic pump curves are shown in Fig. 1. Since the range of good efficiency rarely extends below 80 per cent of rated capacity, considerable waste of power can occur if excessive throttling is required.

System a, Fig. 1, shows a typical closed-circuit cooling-water application for which manual control is usually adequate.

Note that in both systems a and b, Fig. 1, a bleed line from the discharge of the pump is sent back to the liquid source vessel through a restriction orifice. Centrifugal pumps usually may be operated safely *for short periods of time* with their discharge valves closed. However, a certain amount of horsepower will be absorbed by hydraulic losses and friction as evidenced by a temperature rise. As heat is generated, flashing will force the remaining liquid through the suction nozzle leaving the pump running dry. The bleed line is intended to dissipate this heat by recirculating fluid in the lines. A restriction orifice is preferred to a needle valve which may be accidentally closed, or a relief valve which is more expensive. The orifice should be sized to limit the temperature rise to 15 F. If a shutoff valve is required in the bleed line, in order to isolate the pump for maintenance, use of a needle valve in preference to the restriction orifice is justified.

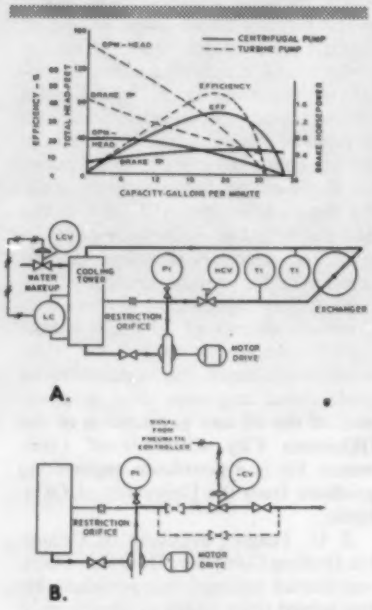

FIG. 1. Typical performance curves are shown for centrifugal and turbine pumps and standard control systems used. (a) Typical manual control used in cooling water applications, (b) Automatic control system.

A common field error is to insert a pressure gage in the vent connection on top of the pump volute. Such a reading may be as low as 60 per cent of the true discharge pressure because of the high velocity in the pump case. For accurate measurements, pressure gage should be placed at or beyond the pump discharge nozzle.

Where NPSH requires a minimum friction loss in the pump suction line, gate valves should be used rather than globe valves. (NPSH is the difference between the absolute pressure at the eye of the impeller and the absolute vapor pressure of the fluid.)

The control valve bypass, shown in System b, indicated with dashed lines, is recommended where no spare pump is available in the system.

The *Turbine Pump* is a centrifugal type which finds few applications in the oil field. However, its characteristic curves are compared with the volute type centrifugal to illustrate that the power requirements for a turbine pump reach a maximum at shutoff pressure. Control, and relief, therefore, should be in the bypass from discharge to suction, similar to a motor-driven reciprocating pump.

Direct-Acting Steam or Gas Reciprocating Pumps

Typical applications of this type of pump are for glycol injection to inhibit hydrate formation; reflux to stabilizer, and heat transfer oil circulation in

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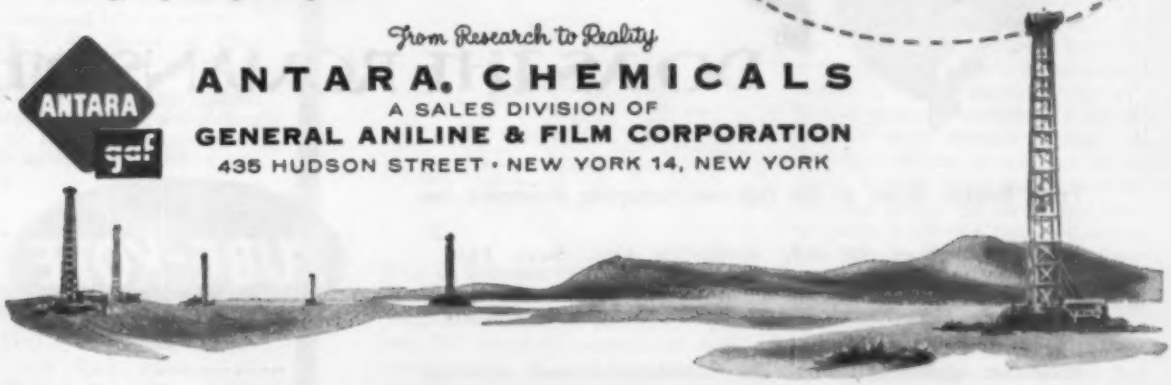

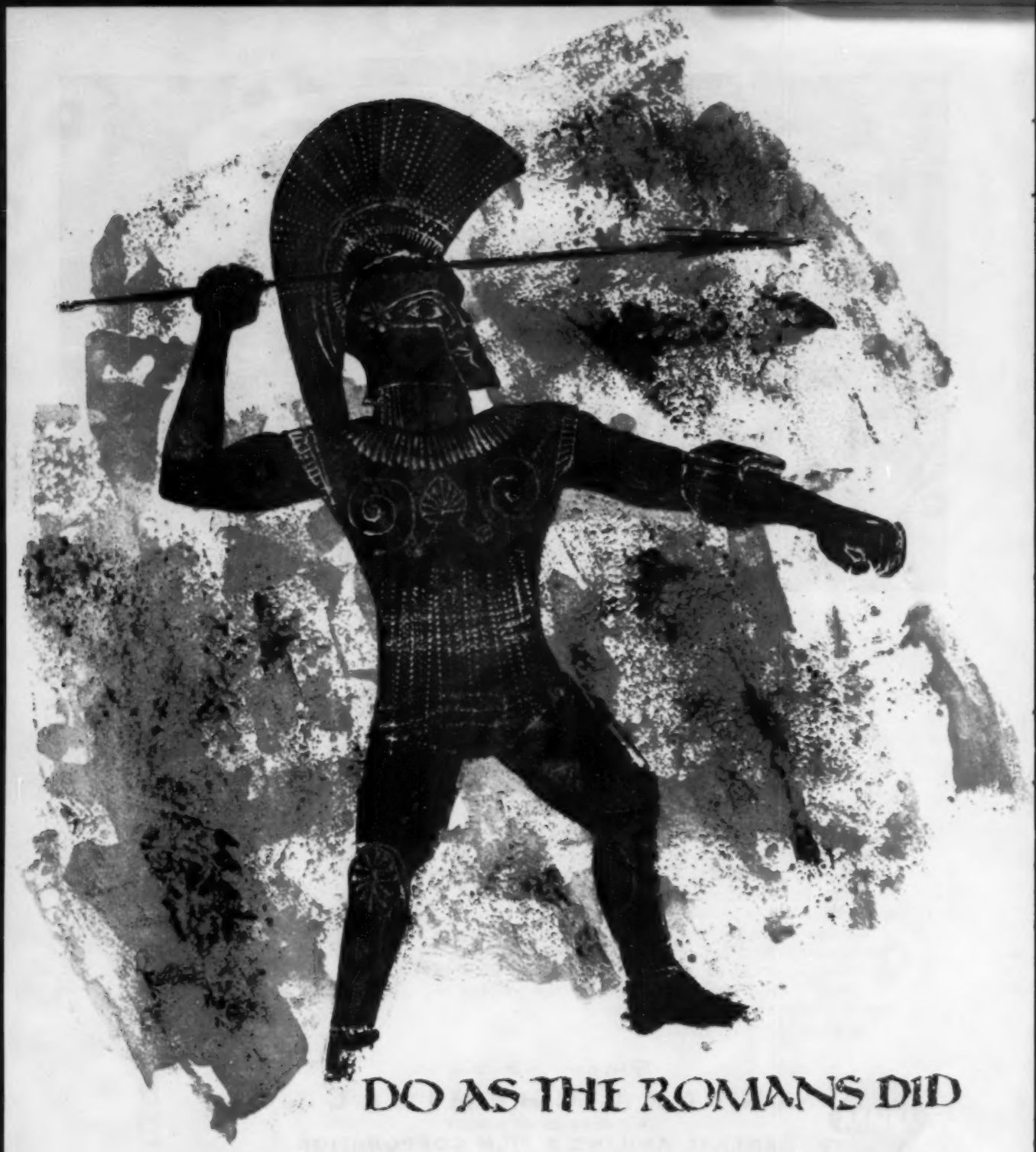

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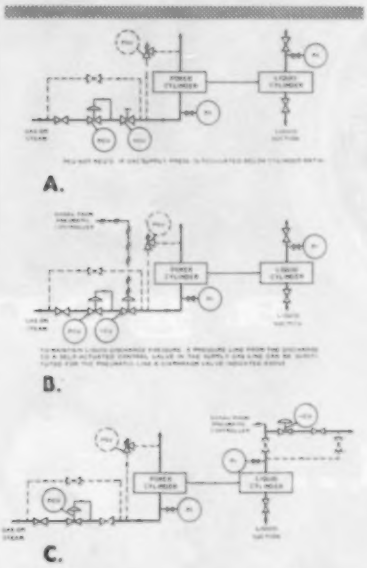

FIG. 2. **Automatic controls designs** used on direct-acting reciprocating pump applications. (a) Manual control of pump speed, (b) PREFERRED METHOD of automatically controlling speed. (c) POOR METHOD of controlling pump speed.

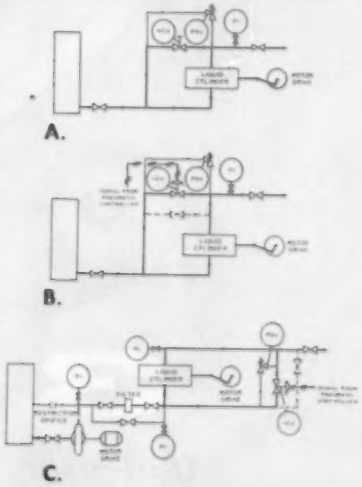

FIG. 3. **Schematic diagrams** show methods of controlling motor driven reciprocating pumps. (a) Manual control, (b) Automatic control, (c) Automatic control of unit equipped with centrifugal booster pump.

The Author

Herbert S. Kindler is an instruments engineer for the oil field division of Black, Sivalls & Bryson, Inc., Oklahoma City, Oklahoma, and has been working with instrumentation and automation since his graduation from Massachusetts Institute of Technology in mechanical engineering. He has been affiliated with the James P. O'Donnell Company, the Brown Instruments Division of Minneapolis-Honeywell Regulator Company and the Catalytic Construction Company, and then founded his own consulting practice in Philadelphia, Pennsylvania. He is a registered professional engineer in New York. Kindler was instrumental in organizing the Instrument Society of America, Oklahoma City section, of which he is now president.

Speed or output of pump is controlled by regulating the gas or steam inlet pressure.

One manual and two automatic control systems are presented in Fig. 2. Note that throttling the pump discharge (system c, Fig. 2) is presented as **undesirable** because it wastes gas and may necessitate using a valve body of higher pressure rating than System b, Fig. 2.

Dashed lines indicate optional equipment as follows: The relief valve shown dashed is only required if the maximum supply gas pressure exceeds the power cylinder rating and/or if the maximum possible liquid discharge pressure, with the discharge valve closed, exceeds the liquid cylinder or piping rating. The bypasses shown as a dashed line are only used on single pump installations.

Constant Speed Motor Driven Reciprocating Pumps

Since flow capacity cannot be altered by regulating discharge pressure, with positive displacement pumps, flow control is effected by bypassing a portion of the discharge back to pump suction. System c, Fig. 3, shows the use of a booster pump to compensate for the pressure drop through fittings and equipment in the suction line to the pump. A bleed line is shown from the discharge side of the centrifugal booster pump, through a restricted orifice, and back to the source vessel. Refer back to "Centrifugal Pumps" for a full explanation of this feature. Note that no discharge control is required for the centrifugal booster pump because the reciprocating pump regulates flow rate. ★ ★ ★

A meter,

a generator,

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Here are some brand-new tachometers that were developed with you in mind. They are electric, completely *self-energizing* instruments for the measurement of rotary-table speed, pump-stroke count, and engine RPM that you will find to be the most versatile and adaptable drilling aids you have ever used.

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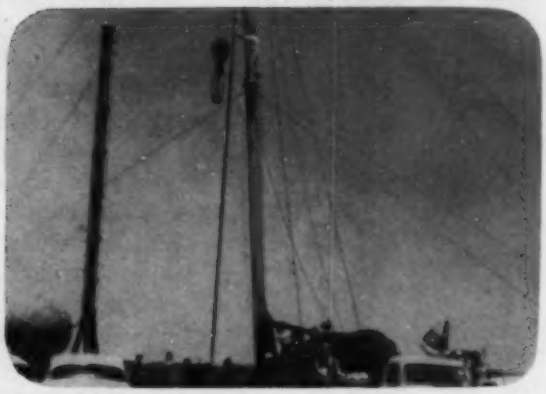
ONE answer to the problem of high water ratios has been provided by the installation of what is probably the world's longest insert type pump. A specially manufactured Double-Displacement pump was installed by the Samedan Oil Corporation on their Andrews D&E 1-E well near Seminole, Texas. Pump is now making approximately 775 bbl of fluid per day on a 26 ft stroke from 6000 ft.

Courtesy of Harbison-Fischer Mfg. Co.

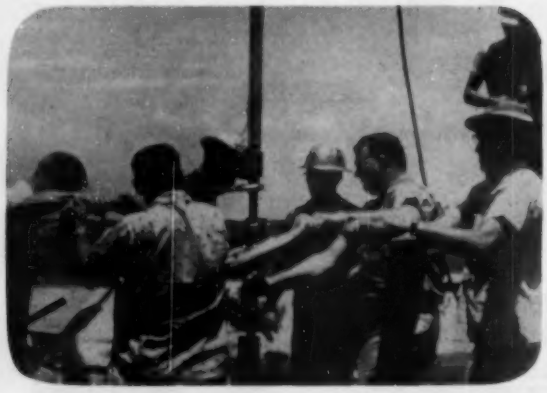
First section hoisted into mast . . .



Braces removed — barrel hung in elevators . . .

Second plunger stabbed on pull tube . . .

Second barrel raised into mast . . .



Pump sections made up . . .

Completed pump going in hole . . .

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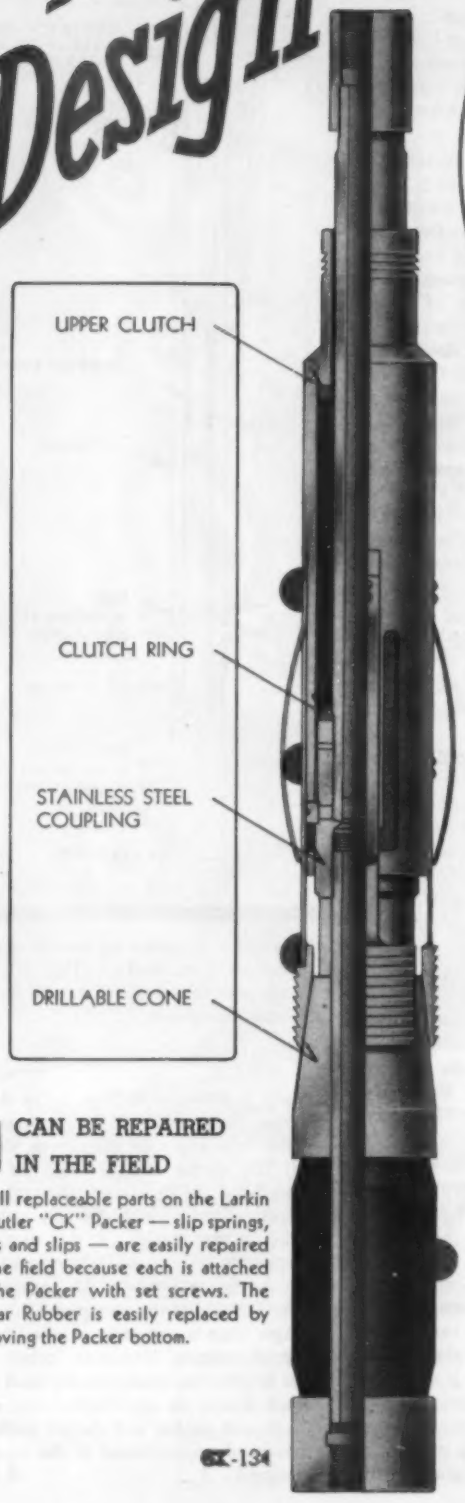

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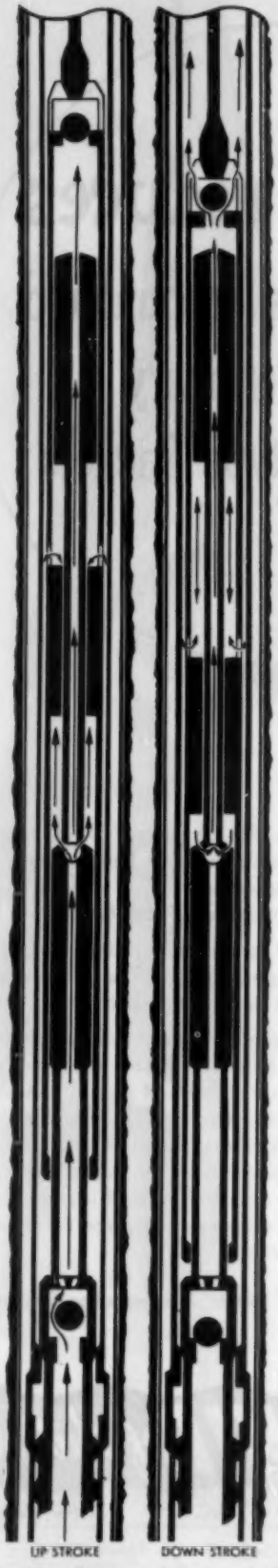


Schematic diagram shows operation of the double displacement rod pump.

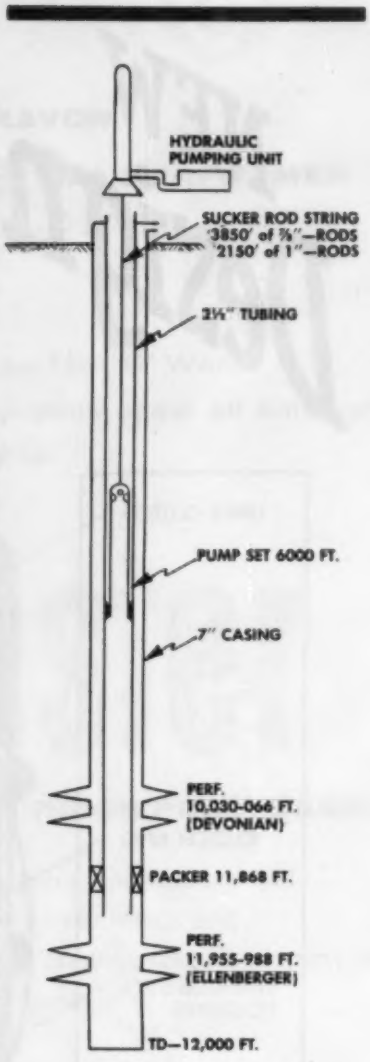
Drilled about five years ago, the Andrews D&E 1-E well is dually completed in the Devonian and Ellenburger formations. Well is producing from perforations 10,030-066 ft and 11,955-988 ft and is completed with 2½-in. tubing on single packer. Presently the Ellenburger is producing around 71 per cent water and has a shut-in static fluid level of 1500 to 2000 ft from the surface. The bottom hole pressure has been estimated to be about 6000 psi. The Devonian is producing through the annulus.

Pump used prior to this installation was a 2½ in. by 1¾ in. by 40 ft by 46 ft sectional liner rod pump which was set at 9000 ft. Operating on five 26 ft strokes per minute, the unit produced 380 bbl of fluid per day consisting of 90 bbl of oil and 290 bbl of water. Present installation is a 2½ in. by 2 in. by 2 in. by 38 ft by 80 ft double-displacement traveling barrel type unit having a measured over all length of 82 ft. The pump is bottomed at 6000 ft using an API bottom pump holddown. The sucker rod string consists of 3850 ft of ⅞-in. and 2150 ft of 1-in. rods topped out with a 1½-in. by 35 ft stainless steel polish rod. The surface pumping equipment is a hydraulic unit having a stroke of 26 ft.

Recently while operating on 4½ strokes per minute, the pump produced 775 bbl of fluid in a 24-hr production test. Production consisted of 220 bbl of oil and 555 bbl of water

In making this installation, the operator used a single pole pulling unit capable of handling rods in doubles, providing a working height of approximately 60 ft. Due to this limitation, the pump was run into the well in sections and the unit assembled while hanging on the elevators. The pump was broken down into two sections measuring 38 ft and a 5-ft stuffing box.

To prevent placing unnecessary stress on the barrel while being raised into the mast, channel iron braces were attached to the barrels. Sections were pulled into the mast with the cat line, braces were removed and the barrel hung in the rod elevators. The pump was assembled as it was run in the hole. The complete pump assembly was then run on the rods in the conventional manner to the setting depth.



Schematic diagram of equipment installation in the Andrews D&E 1-E well. Pump was set at 6000 ft with an API bottom holddown.

Design of the Pump

The pump used in this installation was an insert type, traveling barrel, bottom holddown assembly made up of two plunger and barrel tubes which work simultaneously with a single set of valves. Basically, the unit may be regarded as two pumps operating in parallel which are made up one above the other. A schematic diagram of the pump is provided in Fig. 2. On the up stroke, fluid is through the standing valve into the two chambers shown. On the down stroke, fluid in both chambers is displaced through the traveling valve into the oil column. Due to the design of the unit, displacement is increased 63 per cent over a conventional pump of comparable size. Length of the pump used is 52 ft longer than is presently stocked by the manufacturers. However, other than the length, the components used were stock items. In application, the beam loads and sucker rod design loads are increased proportional to the volumes pumped. ★ ★ ★

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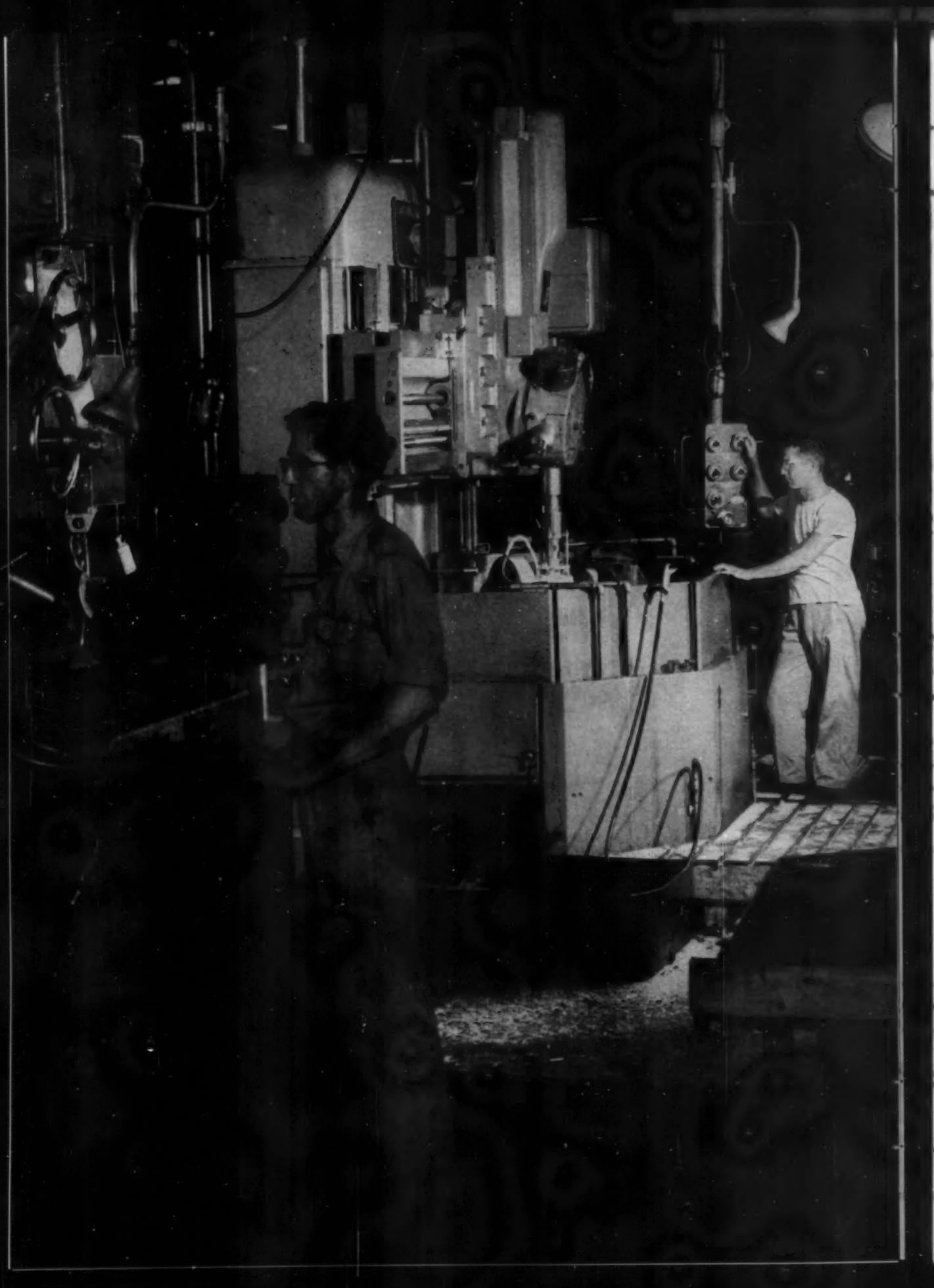

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Today, the company's plant occupies more than 55,000 square feet of floor space with all facilities covering 13½ acres. That's only temporary, of course. Expansion is always under way.

O-C-T machines, like O-C-T products, are specialized and versatile.

The little ones turn out big jobs and the big ones sometimes turn out little jobs.

O-C-T machines take raw, dull-looking hunks of iron and steel and convert them into gleaming pieces of well control equipment that can handle the toughest, the most complicated assignments.

For example, two recent additions to the machine shop cost about $100,000 each.

Their purpose?—Mass production that still imbues the product with an individual personality.

The units can be preset to do specific chores, automatically boring huge castings; boring vertically or at angles; boring tapered holes, holes the same size—all with super speed.

The nerve center of these robot giants is a complicated case of delicate electronic equipment.

In the midst of an automatic boring job, these machines can be halted, switched over to manual control to turn out an emergency job, and then placed back on its original work with no time lost in resetting controls.

Ultra modern machine shops is one reason why O-C-T continues to set production records.

But production records mean nothing unless the products are precision-made.

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At O-C-T they can not use aged machines to be first in the machine age.

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THEY COST O-C-T nearly $100,000 each, but these two new automatics will get emergency jobs to oil operators days earlier.

Design Considerations for . . .

Small Unattended Field Gas Compressors

Reliable basic operating data, location of field station site, future expansion must be seriously considered to develop plans and specifications for station equipment

Millard L. Hipple
Humble Oil & Refining Company
Houston, Texas

IN view of the increasing need for small gas compressors, as is evidenced by the number of current field installations, the proper selection of compressor type and station design is becoming more of an industrial problem. Consequently, it behooves the designer to become more thoroughly acquainted with the many considerations encountered in the design of small horsepower field gas compressor installations. Applications of gas compressors vary widely, but the principal function is to boost the pressure of the gas to a level where the gas can be further utilized.

Gas compressors have wide field use in the oil industry, especially for sales to pipe lines and in gas lift operations. Other applications include the use of gas compressors as booster units, gas injection for pressure maintenance, net gas-oil ratio operations and storage. Applications increasing in popularity include the installation of small, unitized, skid-mounted gas compressors designed to compress heater-treater or stock tank vapors for ultimate processing or sale.

Design Considerations

Even though applications vary, field gas compressor stations are functionally similar in design. Much planning is required to attain a station that is safe for personnel and equipment and easy and inexpensive to operate and maintain. In many cases economical justification would be difficult to attain if full time operating personnel were required. Therefore, the popular trend has been to design the compressor installation to operate with minimum labor and to perform largely unattended. Many companies have the field pumper attend the compressor installation as part of his other duties; the attention required depends upon the nature and type of operation.

In general, relatively small horsepower installations will be discussed primarily in the range of 50 to 250 bhp. where the quantity of gas to be compressed is small and the overall compression ratio is usually relatively high. In many cases the problem is to boost gas from a low-pressure casinghead system operating at perhaps 50 psi into a transmission line or a gas-lift system which might be operating at 800 to 1000 psi. Consequently, the overall compression ratio will range from about 12 to 16. A two-stage reciprocating type compressor best fits these basic conditions and is almost universally employed. Rotary compressors might be used in special applications, however. For example, a motor or engine-driven rotary compressor could be used in compressing heater-treater vapors or gas from atmospheric pressure to a low-pressure gathering system where the discharge pressure would normally be less than 60 psi. For higher discharge pressures increased slippage would seriously impair efficiency with consequent increase of horsepower and fuel requirements. Centrifugal compressors have high volume-low compression ratio characteristics which ordinarily preclude their use in small field compressor installations. Since rotary and centrifugal type compressors have only limited field applications the following discussion will relate only to reciprocating type compressors.

Basic Considerations

Some of the basic considerations required for proper design of a field compressor station are fundamental in any design problem. Table 1 is a representative questionnaire that might be used as a guide to provide the designer with sufficient information to develop plans and to prepare specifications for station equipment. It cannot be overemphasized that the procurement of reliable data upon which the design will be based is a prerequisite to a well-designed and satisfactory operating installation.

Not only is it of particular importance to have accurate predictions of initial conditions of service, but the gas volumes and pressures anticipated in the future are perhaps more important inasmuch as the designer must have this information in order to size properly the components making up the field compressor station. For example, if predictions indicate additional gas will require compression reasonably soon after initial operations begin, it may be economical to install equipment capable of handling the maximum conditions, or in reasonable increments thereof, rather than to install a compressor and its auxiliaries designed to handle the initial conditions of service. Equipping the compressor with larger cylinders than initially required and generously sizing the compressor auxiliaries to include sufficient heat exchanger surface, scrubber capacity, and adequate sized piping will usually provide added capacity for less cost than making revisions and additions at a subsequent date. During this interim period, because of the liberal sizing of the equipment, appreciable operating flexibility would be available to handle variable flowing schedules usually accompanying production of casinghead gas. Other provisions for expansion which can be incorporated in the basic design at very little extra cost include projection of reinforcing dowels in the expansion end of the compressor foundation and tie-in connections for additional piping and equipment.

Another basic consideration of more than casual importance is the location of the field station site. In addition to the desire to locate the station centrally within the gathering system, other considerations should be investigated, such as available utilities, road accessibility, physical obstructions (such as trees), related oil field equipment, prevailing wind, topography, and safety considerations. Since most small field compressor installations utilize air cooling, the orientation of the equipment

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TABLE 1.

Preliminary Information for Design and Specifications for Compressor Stations

I. COMPRESSOR DESIGN DATA

Inlet Gas — For each inlet gas stream determine maximum, average and minimum volumes and pressures, maximum temperature and specific gravity.

Plant Discharge — Determine the maximum and minimum estimated pressures.

General — It would be helpful if a table could be prepared showing the estimated volume and plant suction and discharge pressures by years as well as a hydrocarbon analysis of each gas stream with separator pressures and temperatures. With this information a better selection of line sizes, compressor cylinders, and separators can be made.

II. UTILITIES AVAILABLE

Electrical Power — Is commercial power available and, if so, the voltage, frequency and phase. Also, is this power reliable enough to consider for pump drives, etc.?

Water — Is water available either from existing system or readily obtainable from wells for use as jacket water make-up or should the installation include collection of rainwater from the building roof.

III. CONTRACT REQUIREMENTS

If gas is to be sold under contract, stipulations relating to dehydration, measurement, maximum temperature, and other items which would affect the design should be furnished.

IV. PRINTS AND PLATS TO BE SUPPLIED

Proposed Plant Site Area — Show contours, existing lines, trees, obstructions, equipment, and wells in the area and 200 ft outside plant area. Direction of prevailing wind should be furnished.

Preliminary Gathering and Injection Systems — The line locations will be needed for plant layout. The location of injection wells and gas volumes to be injected may determine the need of dehydration, gas cooling and expansion loops in the injection system.

V. SOIL CONDITIONS

Information on soil conditions should be furnished for foundation design from test holes drilled at the plant site.

VI. OTHER

Furnish all available information on local regulations for construction and operations that would apply to the proposed plant.

with regard to the prevailing wind is particularly important. Unless extremely high atmospheric temperatures are to be encountered, no difficulties are anticipated in designing for satisfactory cooling of jacket water and lube oil. In gas cooling, however, it is not practical to install atmospheric gas cooling facilities to give a closer approach than approximately 15 to 20 F to the atmospheric temperature. In locations where atmospheric temperatures may be above 100F for any sustained period of time, these conditions may preclude the use of air cooling on discharge gas where service or contract conditions require this gas to be dehydrated. In these cases water cooling of the final stage gas may be essential inasmuch as it is possible to cool the gas to be dehydrated to within a 10F approach to the wet bulb temperature, or approximately a maximum of 90F in most areas. Although water cooling may require additional investment, the decrease in water content of the dehydrator inlet gas reduces appreciably the cost for the dehydration facilities.

The design considerations already discussed are applicable to any size gas compressor station, large or small. Since this paper relates only to small unattended field gas compressors, the selection of the compressor unit is of paramount importance in the design of the proposed installation.

Selection of Equipment

The compressor-driver combinations generally available are (1) direct-connected, slow speed (400 to 600 rpm), heavy duty engines, commonly referred to as the "angle" type, where the compressor cylinders are mounted integrally on the engine crankcase, and (2) high speed (900 to 1600 rpm), oil field type power units driving separate horizontal or vertical compressors through multi-vee belts or reduction gear arrangements. Both of these types may be installed as (1) stationary compressors, where the compressor and its auxiliaries and other equipment components are installed and connected in the field; or (2) portable packaged units, where the compressor and auxiliary equipment and related piping are mounted on a skid-type, structural steel base. In fact, it is possible to shop fabricate a unitized, skid-mounted compressor station complete with the usual equipment plus special features, such as inlet regulation and automatic load control, starting and fuel gas supply, emergency and drain connections, all arranged so as to require a minimum amount of field labor for installation and to retain a maximum salvage value. Each type and arrangement of equipment has certain advantages, and to make a choice between them, the following factors should be evaluated for the particular installation.

a. **Horsepower Requirements**—For compressor applications where less than 150 hp is required, the popular trend has been toward the high speed, oil field type, engine-driven compressor unit. The heavy duty, direct-connected type unit is not designed to be competitive in this horsepower range, and consequently the high speed unit requires less initial investment. Regardless of type, most compressors in this horsepower range are procured and installed as portable, unitized, skid-mounted plants.

In deciding upon the selection of a 200 hp or larger high speed, oil field type unit vs a slow speed, direct-connected type compressor, proper consideration should be given to the following factors:

1. Differences in cost of installation.
2. Fuel requirements if a value is assigned to fuel gas.
3. Direct operating costs of labor and supplies.
4. Repairs and maintenance costs.
5. Service facilities and spare parts available in the immediate area of operation.
6. Expected period of operation.
7. Salvage value.
8. Number of anticipated relocations.
9. Familiarity of operating personnel with proposed equipment.

The designer should investigate thoroughly the fuel consumption as guaranteed by the manufacturers of both the heavy duty, direct-connected compressors and the high speed, oil field type, engine-driven compressors. The designer should also investigate the costs of repairs and maintenance anticipated during the life of the project required by one basic type of unit over the other. This is especially sig-

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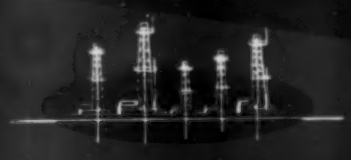

N-2

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N-4

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N-12

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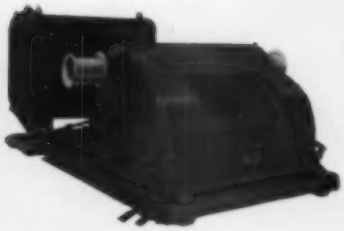
N-95

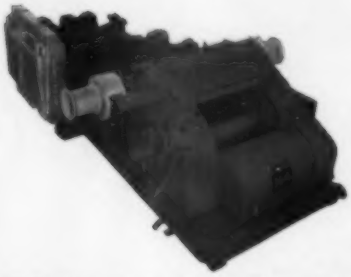


N-3

Portable and easy to operate on shallow drilling or deep servicing. Depth — to 3,500 feet. Horsepower — 140 to 160.

N-45

Highly portable shallow to medium depth rig in torque converter or mechanical model. Depth — to 6,500 feet. Horsepower — 450.



A tough light rig for fast drilling. Depth — 4,500 to 5,500 feet. Horsepower — 200 and 350.

N-55

Medium depth rig. The favorite of drillers from the Gulf Coast to Canada. Depth — 5,000 to 8,000 feet. Horsepower — 525 to 600.

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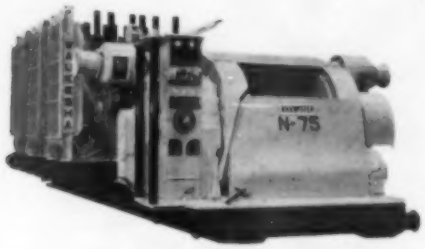
N-75



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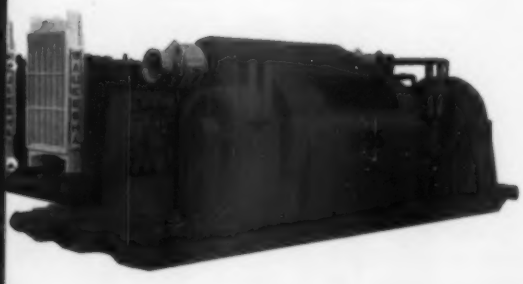

N-85

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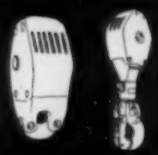
OB-18 (N-4) **OB-12-L** (N-3) **OB-12-S** (N-2)

8-SX N-12 and N-95 **6-SX** (N-75) **4-SX** (N-55, N-45 and N-4)

3-S (N-3 and N-2)



500 TON (N-12) **300 TON** (N-95) **200 TON** (N-75) **120 TON** (N-55)

HT-100 (N-45, N-4 and N-3) **HT-50** (N-2)

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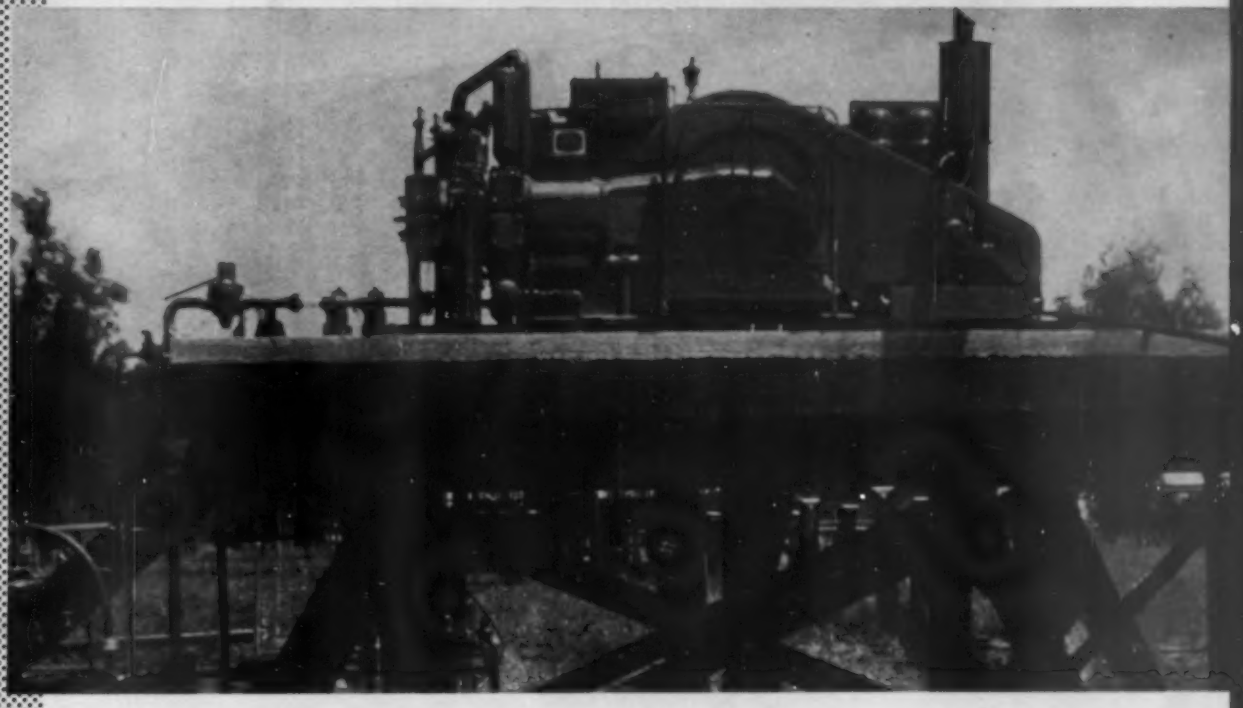

An installation of a Wilson Supply-Ingersoll-Rand Packaged, Portable Compressor in the overflow portion of the flood control area of the Atchafalaya River in Louisiana.

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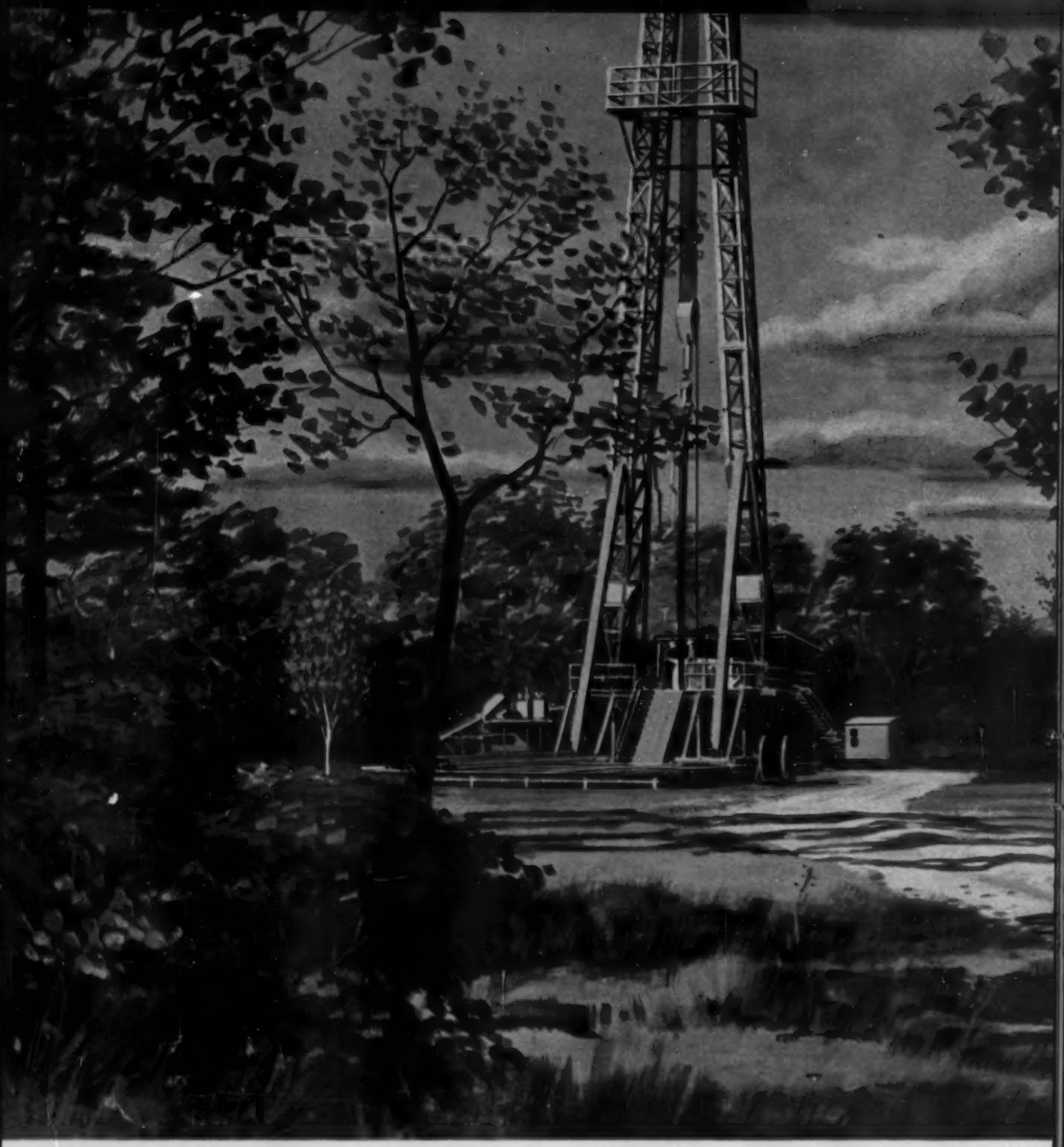

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nificant as the project life is extended inasmuch as the high speed, oil field type engine is driving relatively light weight compressors which are connected through additional moving components such as clutches, bearings, v-belts, drives, couplings, etc.

In the range of 150 to 200 hp there are considerable differences of opinion as to whether the high speed, oil field, engine-driven compressor or the heavy duty, direct-connected type is preferable. In this particular range, which is probably the horsepower range most frequently encountered, the designer must give particular consideration to the value of fuel, cost of maintenance, salvage value, number of relocations anticipated, number of stages of compression, and numerous other lesser factors, all in relation to the project life. Here again the shop fabricated, unitized, skid-mounted compressor unit is usually installed.

d. **Life of Project** — For a project operation of long duration, say 10 years or more, the designer should consider the advantages or disadvantages of installing the two basic types of engines. In many instances the initial advantage of one type could be more than offset as the project life is extended. These advantages may become even more significant as the installed horsepower increases.

Connected closely with the life of the project is the question of whether to skid mount and unitize allied auxiliary equipment, such as scrubbers, heat exchangers, control valves, etc. If the operating period of a proposed facility is short (less than five years), possibly a skid-mounted unitized unit might be preferable because of its portability and salvage value. One criterion for a portable unit is that the unit must be light enough in weight and small enough dimensionally so that it can be economically transported on standard trucking equipment and legally moved from point to point without the necessity of special hauling permits. Assembly of this equipment in a relatively small area limits the operating and maintenance accessibility compared to the stationary type installation, where the scrubbers, heat exchangers, compressor auxiliaries and related equipment and piping can be installed away from the immediate area of the compressor so that maximum operating and maintenance accessibility is provided around all equipment. Depending upon the individual requirements, the cost of installing a stationary, heavy duty, direct-driven compressor station may be no more than the cost of a comparable skid-mounted compressor station since costs of the heavy structural steel skid and the shop fabricator's engineering, assembly charge, overhead and profit

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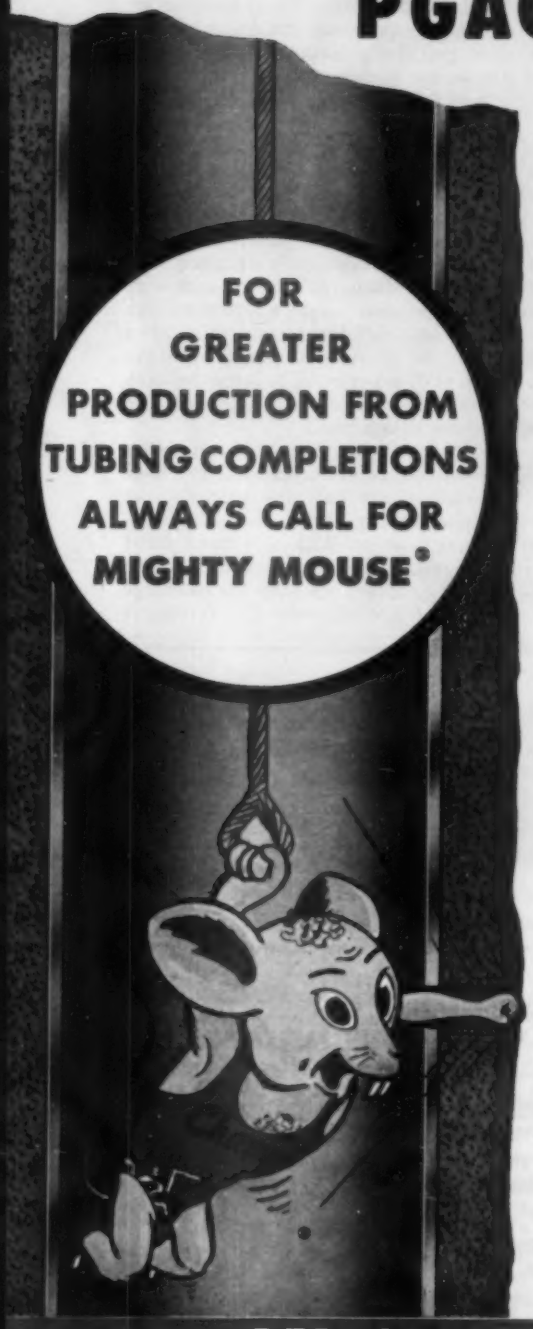

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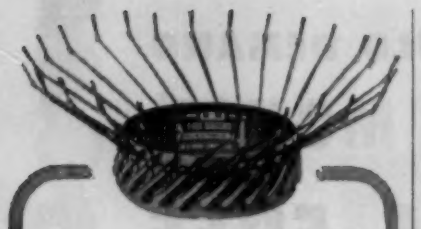

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may offset the cost of installing permanent facilities.

In this discussion no attempt has been made to advance one type of installation above the other, but rather to acquaint the designer with some inherent advantages of each. For a particular application, it is probable that additional considerations will arise that will vitally affect the selection of the type of unit. Values to be assigned to each of the several considerations in making this selection should be left to the discretion of the designer.

Safety Considerations

In the design of any installation to operate largely unattended, it is necessary to incorporate certain features of automatic control to protect equipment in case of malfunction. For protection all engines are equipped with standard shutdown devices for low lube oil pressure, overspeed and high jacket water temperature. The engine can be shut down either by grounding the magneto or blocking and venting the fuel. Additional features may be incorporated at the discretion of the designer to conform with company standard practice or local safety regulations.

A scrubber should be installed immediately upstream of each stage of compression and should include an automatic drain and a device for shutting down the compressor in the event of high liquid level in the scrubber.

Since a compressor cylinder is designed to handle a certain volume of gas under specific conditions of speed and suction pressure, it is essential to control this pressure within certain limits. For example, if the suction pressure is too high, it is possible to overload the compressor frame or driver as a result of the compressor cylinder handling more than the design volume of gas; if the suction pressure is too low, the discharge temperature of the gas from the compressor might be above safe limits because of the heat of compression and it could thereby result in valve, packing, rod or piston failure. Consequently, it may be desirable to install a high discharge temperature shut down, particularly if the compressor cylinder is equipped with only one discharge valve on each end. For additional safety, a high discharge and low suction pressure shut down may be provided to function in the event of a gathering line rupture or a station discharge line pressure increase above design limits.

One common practice of connection with control of suction pressure is to automatically vary the speed of the driver to maintain a reasonably constant pressure. With or without speed control, a cycling regulator may be used to divert gas from the discharge side of a compressor and throttle it

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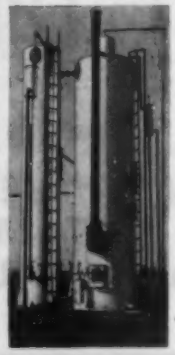

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back into the suction side, thus maintaining a minimum suction pressure to smooth out the engine operation and to assure gas circulation. This procedure has the disadvantage of wasting horsepower, but in many instances it is required to maintain satisfactory compressor operation.

Another practice for preventing excessively high suction pressure is to employ either a pressure reducing inlet regulator or a back pressure regulator to flare. In most casinghead gas gathering systems either method is satisfactory, but in compressing gas well gas, the inlet regulator should be used in cases where the gas may not be flared. On installations of the latter type the wells should shut in automatically or the gathering system should be designed for the maximum wellhead pressure.

As a supplement to the usual automatic controls, it is considered wise to have strategically located within the station a minimum of two manually operated, shutdown stations. These controls can be used to shut down the compressor from a safe distance in case of an emergency.

In accordance with good engineering practice and as insurance against corrosion and other intangibles, all piping within the station boundaries should be designed in accordance with the ASA Code for Pressure Piping, Section 3, "Refinery and Oil Transportation Piping Systems," or Section 8 of the same Code "Gas Transmission and Distribution Piping Systems."

The safety considerations that have been discussed are not intended, of course, to be all of the points deserving of thought before the final plant design is accepted.

Conclusion

To conclude, it is evident that the many current installations of field compressors emphasize the need for the designer to become familiar with the numerous requirements for proper selection and design of small field compressor stations. Due to the various considerations and factors influencing both the design and selection of the facilities, each application must be decided on the individual merits of the proposed operations. The considerations presented in this discussion are not intended to be a full coverage of the subject problems, but merely to point out some of the pertinent factors which may influence the design.

Acknowledgment

This paper was presented at the eleventh annual Gas Technology Short Course, held at Texas College of Arts and Industries, Kingsville, and sponsored by the Southern Gas Association, May 30-June 1, 1956. ★ ★ ★

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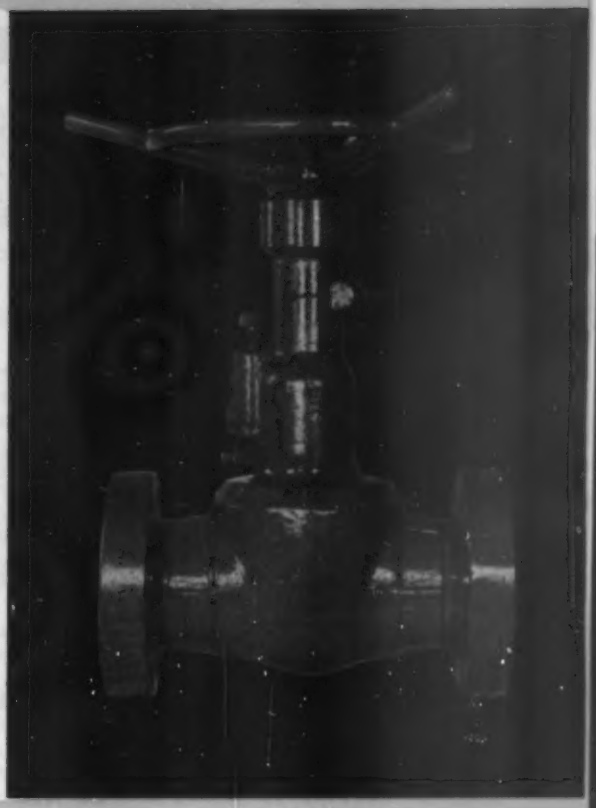
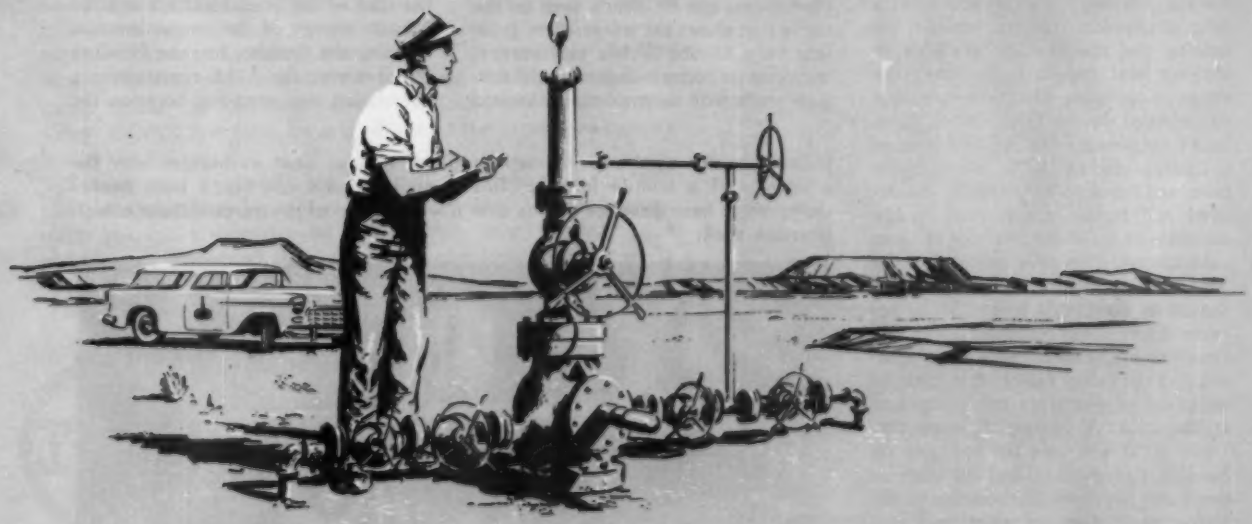




Design Considerations for...

Gas Fired Field Processing Equipment

Optimum field performance must be assured in the use of gas consuming heaters, treaters, and reboilers; required heat loads, type of heating units and safety factors must be considered in selection of equipment

Edwin C. Young
Black, Sivalls & Bryson, Inc.
Oklahoma City, Oklahoma

FOR many years the market for natural gas was limited due to inadequate handling facilities. When excess gas could not be utilized on the lease and had to be flared for disposal, little consideration was given to the economics of operating gas fired equipment or gas driven pumps. With the advent of the natural gas pipe line systems producing an outlet for a vast amount of gas, utilization of natural gas on leases has come under more careful scrutiny. Therefore, it has become necessary to study gas consuming equipment to determine whether maximum useful utilization is being made. Consideration must be given to the factors involved in the design of gas fired equipment and gas powered pumps and to the precautions that should be exercised by field personnel to assure optimum field performance.

Heating Element Basic

In choosing gas fired equipment for a job on the lease, a heating element must be chosen that will be adequate for the job but not oversized from a heat standpoint. Heaters, treaters, reboilers, and the like are available in varying heat capacities to cover the range of operating conditions normally experienced in the field. For a given field condition the first step in choosing a heating element is to calculate the heat load required for attaining the desired end results. Charts are readily available to assist the operator in these calculations. The next problem to be answered is to the type of heating that should be used, that is, to choose between direct or indirect fired units. This choice usually can be resolved by considering the safety factors that must be exercised in operating the equipment in the field. A heating element correctly sized will save the operator on his initial investment and on costs of operation if proper adjustments of the burner gas system are maintained.

Design Features

In the design of gas fired equipment, there are several factors that must be considered before a design can be established. In order to co-ordinate these factors into broad subdivisions, consideration will be given to firebox, stack, burner and pilot light, shell and tube designs in this order. Only the case of the indirect heater will be covered in this discussion, although similar analysis can be used for designing the firebox assemblies of other types of systems.

The firebox represents one of the most difficult parts of the heater to design from a theoretical standpoint. It would be ideal if the combustion process produced uniform temperatures along the firebox but such is not the case. The temperature varies from a region of high temperature in the combustion zone to one of lower temperature at the stack breeching. A secondary effect on the heat transfer is the thermal circulation that occurs in the fluid on the outside of the firetube. This phenomena can be clearly seen on the curve that shows the temperature gradient for a U-tube firebox (see curve), temperature being measured in the firetube walls with thermocouples located on the top, bottom, and side centerlines.

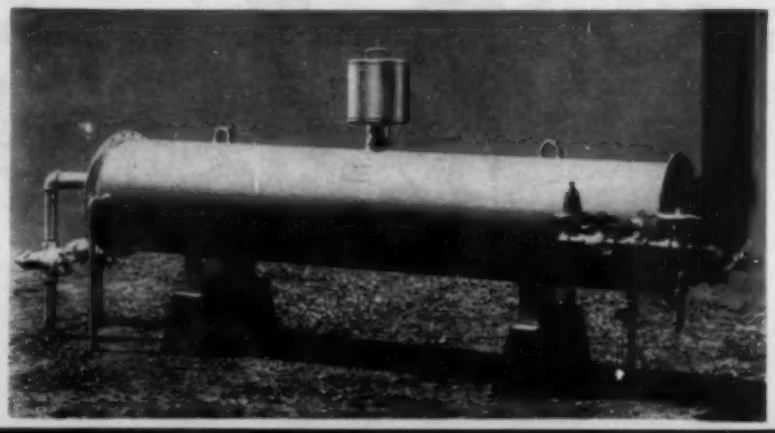
The firetube design is based on the results of tests by AGA Testing Laboratories and published in Research No. 24. From this study and empirical formula was developed in which the thermal efficiency was proportional to the effective length of the firetube squared divided by the input rate of Btu per hour. The final form of this equation is

$$E = 20\text{Log}_{10}\frac{L^2}{R} + 71$$

Knowing the input rate in 1000 Btu per hour and for a desired thermal efficiency (for a range of 60 to 85 per cent in the AGA tests), it is possible to calculate a firetube length.

The AGA tests showed that thermal efficiency was not a function of firetube diameter. In selecting the diameter of the firetube it is necessary to have cross sectional area such that the velocity of the combustion gases is sufficiently low enough to produce a frictional resistance that will be less than the sum of the available draft and the Kinetic energy of the air-gas mixture entering the firetube. For the firetubes tested during the AGA experiments a correlation was obtained between the

Indirect heater combines the advantage of tubular heat exchanger with the efficiency of a built-in furnace. This is an immersed coil liquid bath heater designed to heat gases or liquids over a wide range of pressures without a high pressure shell.



AXELSON PICTORIAL

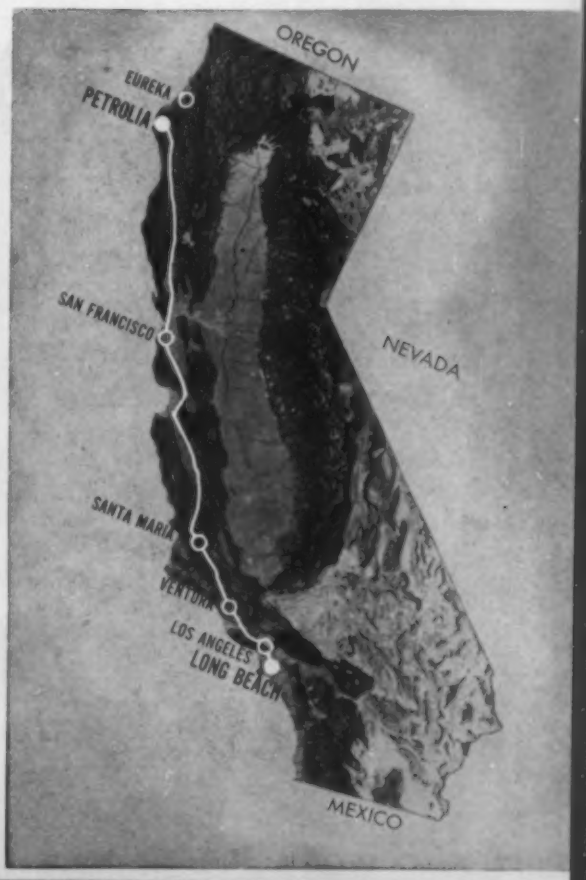
SATISFIED CUSTOMER. Tad Travers (left) President of Brookline Oil Company, Los Angeles, shown with Don Moses, Axelson representative from Long Beach, who delivered the pump to Petrolia, California, 700 miles away. Travers says, "Axelson got us out of a bind. That's one outfit you can always depend on."

DRIVES 700 MILES TO DELIVER A PUMP

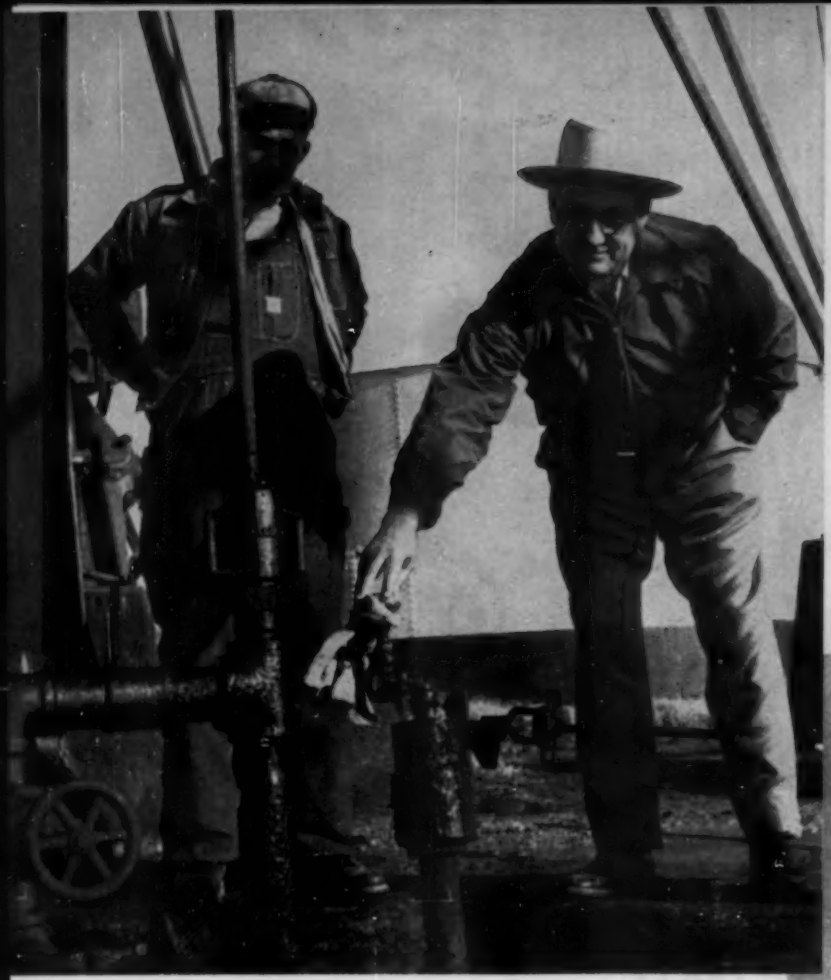
At Petrolia, California, (about 50 miles south of Eureka on the coast) the Brookline Oil Company had a well down. It was during a 3-day Labor Day holiday and no one could get a pump to them until after the week-end. In desperation, Tad Travers, President of Brookline, called Axelson in Los Angeles and told them the problem. The type of pump needed was located in the Long Beach store.

There was no way of getting it to the well by any available means of transportation. It was too big to go on a plane. So Don Moses, Axelson representative from Long Beach, strapped the pump to his car and took off for the location over 700 miles away. Driving non-stop, he arived just as the pump was coming out of the hole.

Travers was so glad to see Don pull up at the well site with the new pump that he cooked him a barbecue. "Axelson is one outfit you can always depend on," Travers says. "As far as our company is concerned, Axelson has no competitors."



FRESH PUMP DELIVERY. The route taken by Don Moses on his non-stop journey from Long Beach to Petrolia. The first oilwell in California was drilled in Petrolia by Leland Stanford in 1864. Roads were so bad that well drilling equipment was shipped in by water. The oil (48 gravity) was called "rock oil" and was used for medicinal purposes. It was carried out in demijohns slung to the backs of mules.

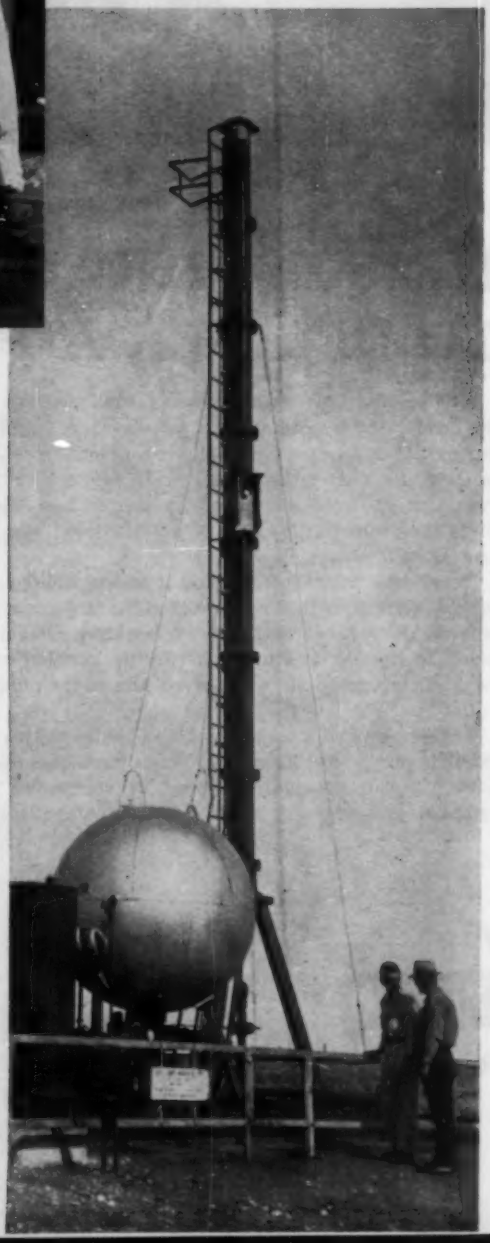


A MILLION BARRELS. This is one of 4 wells on the Ralph E. Fair lease in Talco, East Texas. All are equipped with Axelson subsurface pumps and sucker rods. These wells have been pumping for 18 years and have lifted over a million barrels of oil *without once being pulled.* Checking the Batson #1 (46 B/D, 23 gravity, 4,150 ft.) are Willie Buchaman, Pumper (left) and Omer Cole, Lease Superintendent.

DEEP STUFF. At six strokes per minute, this Axelson Hydraulic Long Stroke pumping unit lifts 100 B/D of 48 gravity crude oil *from a depth of 11,500 ft.* (Well No. 1, R. K. Cone Lease, Warren Petroleum and Jake L. Hamon, Lea County, New Mexico). Checking the performance is T. C. "Ted" Tilgham, Pumper, (left) and Sandy Brock, Axelson Representative working out of Hobbs, New Mexico.

AXELSON

FIRST OFFSHORE. Drilled in 1864 by an Italian at El Salto, Peru, this well is believed to be the first offshore well in the world. Now the property of Empresa Petrolera Fiscal, it is still pumping. Axelson sucker rods are in service in this well and elsewhere in the field. Gross Equipment, S. A. is the Axelson distributor in Peru.



400 PUMPS. Lee Nave, Axelson Area Manager, sent in this picture of Axelson's pump repair crew at Lagunillas, Venezuela, in the middle of the Lake Maracaibo oilfields. He writes, "This crew was averaging 400 pumps a month at the time this picture was taken."

AXELSON PICTORIAL

HAPPY HUNTING. Last Fall, a group of oil men left Taft, California, for Utah where they bagged this 6-point buck (32¾" spread). It was the biggest deer reported in southwest Utah in '55. Left to right (standing): Red East, Standard Oil Company of California; George Napoleon, Socal; Harry Easton, M. H. Whittier Co.; (kneeling Gerald Parcel, Socal; Rod Napoleon (who shot the buck), Socal; Red Carroll, General Petroleum Corp.

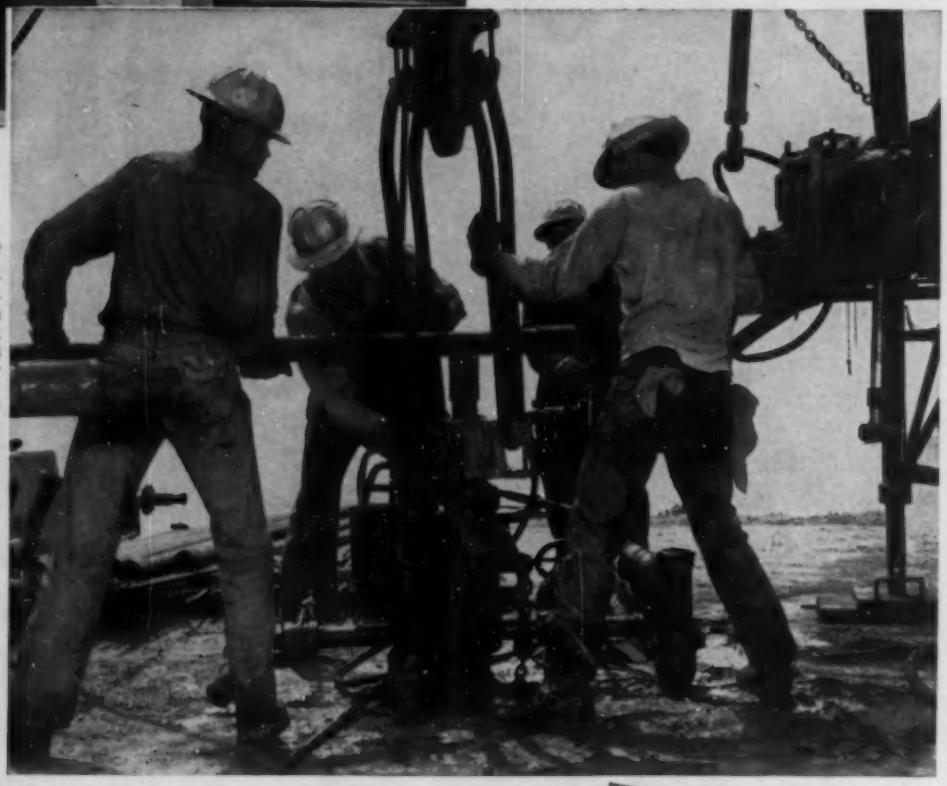
39 WELLS. Forest Oil Corporation has 39 wells in the East Goldsmith Field, Ector County, Texas, equipped with Axelson rods and pumps. Most are pumping from the Pennsylvania at 8,600', the rest are Holt production at 5,000'. A few flowing wells are scheduled to go on pump later in the year and Axelson rods and pumps have been specified. (Left to right) M. W. Johnson, Pumper; S. J. Ingram Jr., Space Hopper; S. J. Ingram Sr., Production Foreman; Gene T. Ingram, Door Slammer.

100%. Standing beside the T. M. Armstrong #24 at Gladewater, Texas, is Lloyd Stevens (left) Pumper, and O. B. Moon, Farm Boss. From the polished rod to pump shoe, this well is Axelson equipped: Axelson Kup-Pak pump (2½"x2"x12'), ¾" #60 Axelson Sucker Rod (3,600'), Axelson #60 (1¼"x11') polished rod, Axelson Stuffing Box, Mario Packing. This packing has been running over 18 months without requiring replacement.

BOOSTER. Taking inventory of the new gas booster installed by the Continental Oil Company in the Short Junction Field, is Harold Smith (left), Maintenance Engineer and Guy Lane from the Accounting Department at Ponca City, Oklahoma. This field is in Cleveland County about 15 miles southwest of Oklahoma City and is the hot spot in Oklahoma at the present. Continental Oil, a good customer for Axelson rods and pumps, has 65 wells producing from the Hunton Lime at 8,000' to 8,082'.

AXELSON PICTORIAL

PUBLIC DEMONSTRATION. Harold F. Allen, Science Instructor at Coalinga College, California, uses a model of an Axelson RLA (rod-type) subsurface pump to explain the principle of artificial lift to his engineering students. Axelson gladly makes available these model oilwell pumps to schools and colleges for classroom study. A 15-minute demonstration will often save hours of classroom discussion and blackboard diagramming.



TUBING RUN. High on a hill overlooking the blue Pacific at Capitan, California, General Petroleum Corp's well service crew runs tubing back into the well while Hydro-Test runs a simultaneous check for tubing leaks. Equipped with an Axelson 2" RLB Pump and Axelson ¾" #59 Sucker Rods, this well makes 12 B/D of 28 gravity crude from 2,600 ft. (l. to r.) Edwin Bruce, June Garland, Burl Hankey (Gang Pusher), Cecil Sutton.

No. 6

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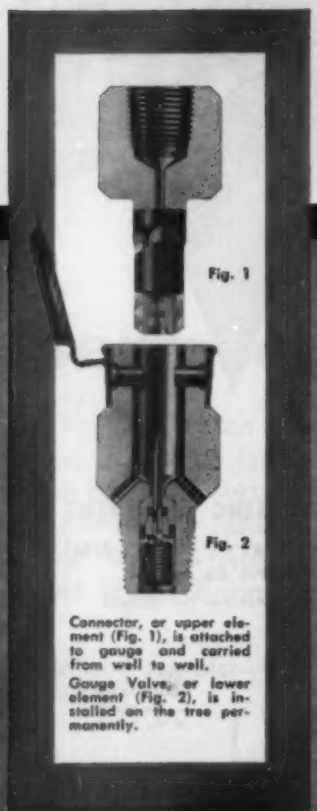

Connector, or upper element (Fig. 1), is attached to gauge and carried from well to well.

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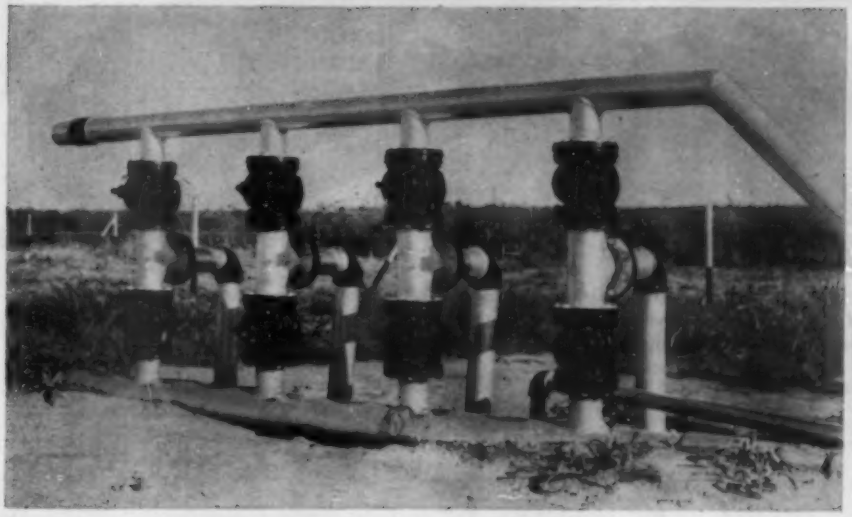

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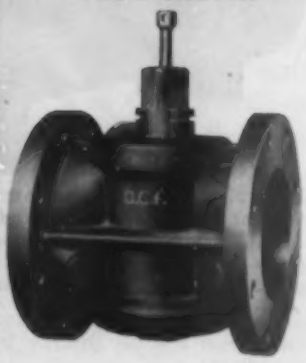

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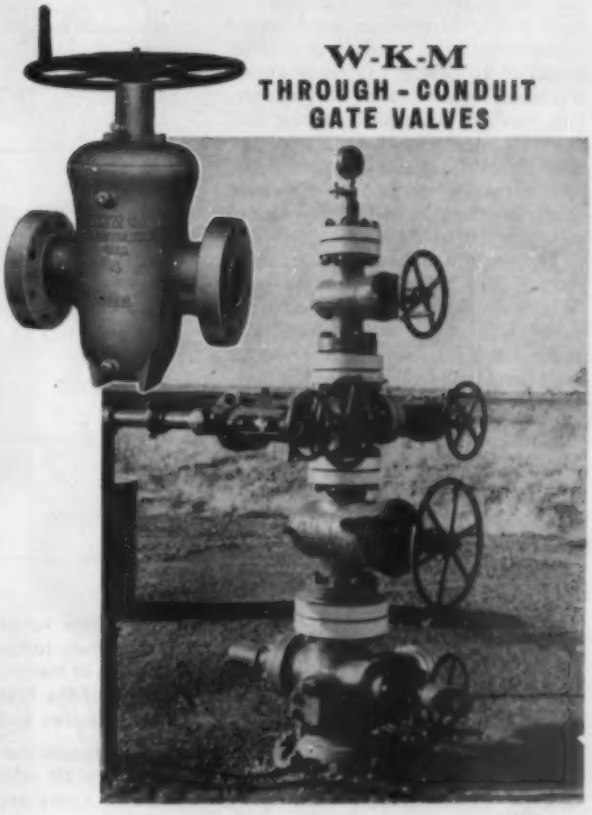

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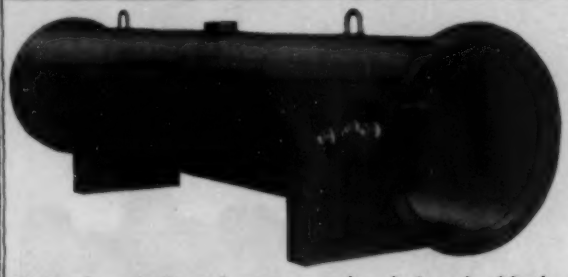
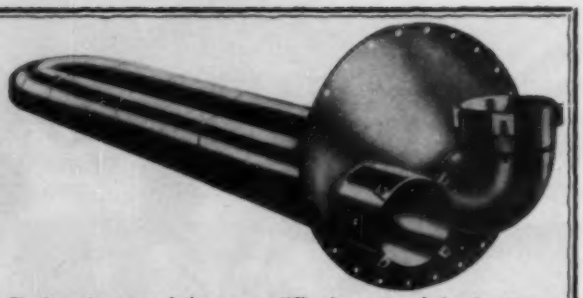


Shell of an indirect heater must be designed with the thought of compactness in mind, have a minimum volume of heat transfer material, and be sealed to prevent loss of this material during operation.



Firebox is one of the most difficult parts of the heater to design, since uniform temperatures along the U-tube, shown here, are not uniform.

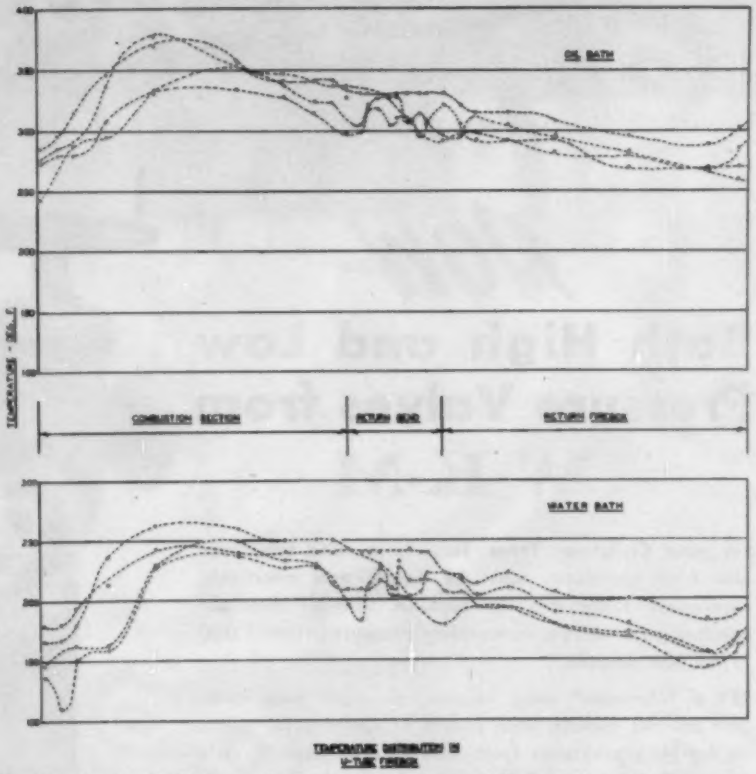
heat input per square inch of firetube cross-section and the effective length of the firetube.

$$R/A = 5000\sqrt{\frac{10}{L}}$$

As pointed out in the report this relationship is conservative. Constants as high as 15,000 produce good results under certain conditions. For a given length of firetube as calculated above, it is possible to determine the cross-section required. Since standard pipe sizes are used for firetubes, it is now possible to select a diameter that will fulfill the requirements. Any adjustment in effective length can be taken care of in the height of the stack.

The Stack. Stack height is one parameter of the heater design in which little or no design data has been published. The AGA tests showed that under ideal conditions the output of the heater could be increased with increased stack height; however, this was not possible without sacrificing thermal efficiency. Data are available for large stacks used on steam power plants but very little on the sizes found on the lease. A complete study on stack design with and without stack hoods should be undertaken to determine the optimum stack design for lease equipment.

Burner and pilot light. In selecting the type burner and pilot light to be used, it is necessary to have units that will perform efficiently and be reliable. The pilot light must be capable of sustaining a flame under all operating conditions. For this reason a pressure pilot light with a hot tip capable of self ignition for momentary blow-outs is most desirable. The main burner must be capable of sustaining a flame and must produce good mixing of gas and air prior to ignition so as to produce efficient combustion. The burner orifice must be selected to pass sufficient gas to meet the heat capacity of the firebox for the burner supply gas pressure to be used. The primary air adjustment is important to get good mixing between the gas and air and must be designed so that the adjustment can be locked so as to maintain the initial setting. The secondary air adjustment is made to produce complete combustion and should be capable of being locked as in the case of the primary air.



Temperature variations are large in the firebox as illustrated on these curves. Temperature ranges from a high in the combustion zone to one of lower temperature at the stack breeching. A secondary effect on the heat transfer on the outside of the firetube. Temperatures were measured in the firetube walls with thermocouples located on the top, bottom, and side centerlines.

The shell. The design of the shell must be undertaken with the thought of compactness in mind. It must be of a diameter and length to contain the firetube and allow for good thermal circulation of fluid to effect optimum heat transfer from the firetube to the tubes. It must be designed to have a minimum volume of heat transfer material and sealed to prevent loss of this material during operation. Water saver pots or other types of surge chambers should be used to take care of the expansion of the heat transfer material during heating and to condense any vapors that may be evolved during the heating operation.

Coils or tubes of the heater are specially designed for the specific application. This design is based on a maximum heat transfer coefficient and a minimum of pressure drop. The coil must be submerged in the liquid at all times to assume optimum operating performance.

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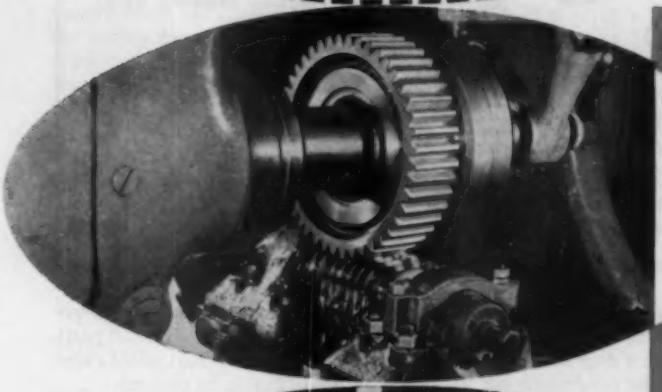

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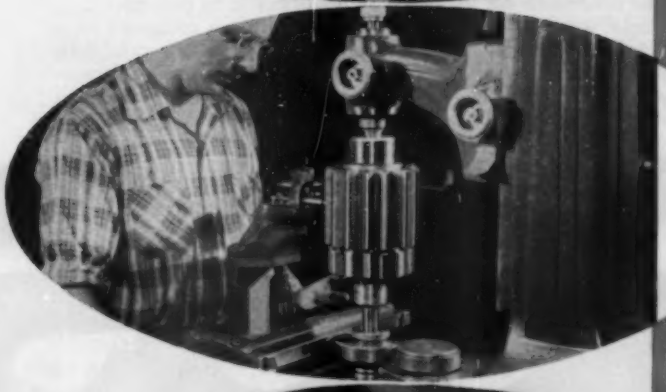

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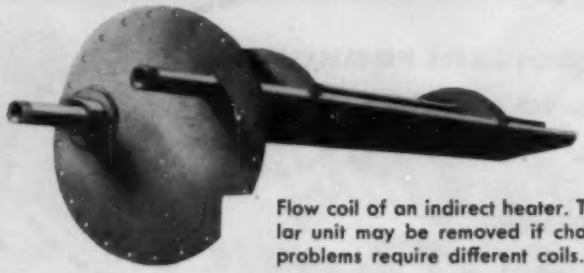
In the design of the supply gas system for the burner and pilot light, two factors are paramount. First the unit must be designed so that safety of personnel is to keep all controls for the system from in front of the burner and away from areas where high temperatures are prevalent. Another feature that should be included is side lighting of the pilot light. This keeps the operator away from the front end or burner cover which has been known to blow off on occasion when the firetube has become filled with gas prior to ignition. Placing of guard rails or insulation around regions of high temperature should also be considered as an additional safety feature.

For assuming continuous operation and providing built-in safety features, the proper selection of control equipment is essential. A self-igniting pilot light capable of re-ignition on momentary flame blow-out has been discussed. For complete safety a safety shutdown system should be installed that shuts in the main burner gas supply if the pilot light fails. This prevents the main gas burner from turning on when no pilot light is available for ignition.

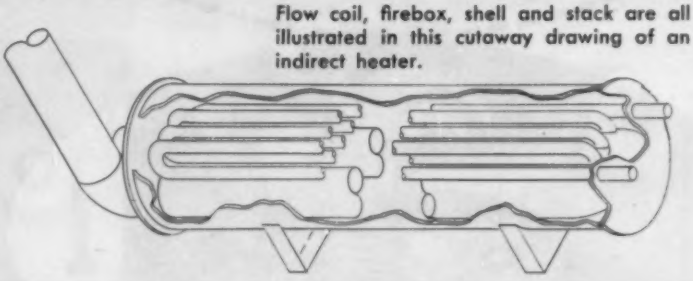
The supply gas system takes gas from a source at a pressure in excess of the required low gas pressure. The gas pressure is reduced in a regulator which causes a refrigeration effect and retrograde condensation to occur, the magnitude depending on the pressure of the source. When this occurs it is necessary to place a drip in the supply gas line to keep the condensate out of the system. In cold weather, it is often necessary to heat the supply gas after the pressure cut to prevent formation of hydrates. It is advisable to install a strainer in the line downstream of the drip to keep small particles out of the system that might cause the burner orifice to be plugged.

Firing the burner is controlled by a thermostat that is used to control bath temperature or fluid outlet temperature. The thermostat controls the main



Flow coil of an indirect heater. This particular unit may be removed if changing field problems require different coils.

Flow coil, firebox, shell and stack are all illustrated in this cutaway drawing of an indirect heater.



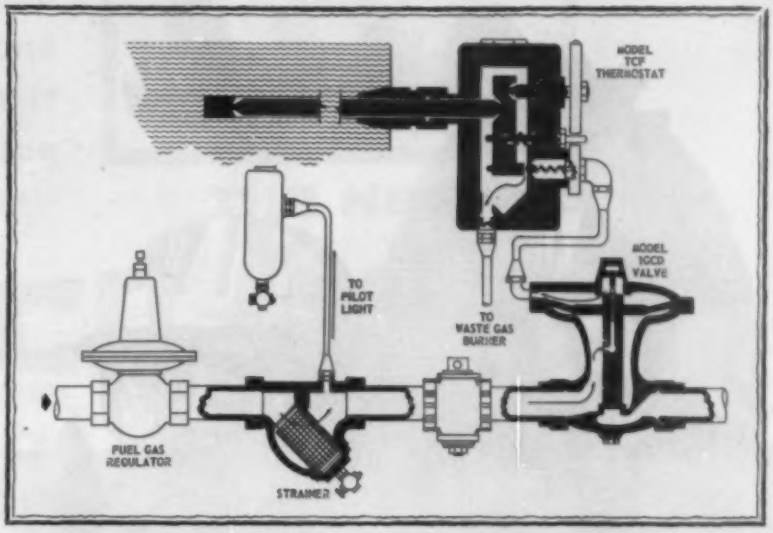
SIXTEEN 's

burner supply gas diaphragm valve, opening the valve when the temperature drops to the lower control point and cuts it off after the temperature attains the upper control point. In smaller units the thermostat may be used as the burner supply gas valve. Supply gas for the pilot light is taken off upstream of the main gas valve to provide a continuous supply of gas to the pilot.

Burner Performance

In field operation the operator should understand the factors to be considered for best burner as well as overall heater performance. In the burner itself, it is necessary to have the orifice properly sized for the gas capacity to produce the heat required. Burner manufacturers have charts available which recommend orifice diameters as functions of flow rate and supply gas pressure. The operator should see that the orifice is clean and free of burrs at all times since the ratings are based on these conditions. The burner gas pressure should be maintained at the pressure recommended for the orifice diameter used.

Adjustment of the gas-air ratio is important in obtaining complete combustion and optimum burner performances. This adjustment is made by varying the primary and secondary air until complete combustion is realized. The only exact method for adjusting a burner properly is the use of an Orsat analyzer to check the products of combustion in the stack. When the analyzer shows that there is no carbon monoxide present in the stack gases, then complete combustion has been obtained. Primary air adjustment determines to a great extent the color of the flame while the secondary air adjustment supplies the additional air required for completely burning the fuel gas. Excess air decreases the thermal efficiency of the unit because the excess air has to be heated to stack gas temperature. In general the best thermal efficiency is obtained with a blue flame with enough secondary air to get complete combustion. A blue flame is not recommended, however, because it produces higher



Supply gas system takes gas from a source at a pressure in excess of the required low gas pressure. This is reduced by the regulator, causing a refrigeration effect and retrograde condensation. For this reason a drip and strainer is included.

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1 Cross-Over Choke	S	S	S	S	S								
2 Regular Flow Choke	S	S	S		S			S	S				
3 Dual Side-Door Choke	S	S	S		S			S	S				
4 Dual Separation Tool	S	S						S	S	S	S		
5 By-Pass Side-Door Choke	S	S	S		S				S				
6 By-Pass Separation Tool	S	S							S		S	S	
7 Side-Door Choke	S	S	S		S				S				
8 Separation Tool	S	S							S	S	S		
9 Lower Zone Acidizing Tool	S	S	S		S			S	S				S
10 Upper Zone Acidizing Tool	S	S						S	S	S	S		S
11 Circulating Tool	S	S	S					S	S		S		S
12 Side Port Nipple Choke	S	S	S		S	S			S				
13 S-P Nip. Separation Tool	S	S				S			S	S	S		
14 Plug Choke	S	S									S		
15 Lower Zone — Ring Check Acidizing Tool	S	S	S		S		S		S				S
16 Upper Zone — Ring Check Acidizing Tool	S	S					S		S	S	S		S

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temperatures in the combustion zone and is responsible for firebox burnouts. A blue flame tinted slightly yellow is almost as efficient and eliminates the concentrated combustion zone. Stack temperature is an indication of complete combustion since the maximum stack temperature occurs at this point. Only by Orsat analysis can the air-fuel ratio be properly adjusted to produce complete combustion.

Thermostat Settings

Once the burner is properly adjusted and the unit put on stream it is necessary to have a thermostat to maintain the temperature required. In heating gas or oil there is a minimum temperature at which the system will produce the end results desired. The thermostat must be set at or above this temperature. It is important that the operator keep as close to the minimum temperature as possible. For example, it takes ⅓ of a cubic foot of gas to raise the temperature of a barrel of typical oil one degree Fahrenheit and 36 cu ft of gas to raise the temperature of one MMscf of average gas one degree Fahrenheit. Although these seem to be relatively small, when one considers the flowing rate through the heater and the temperature differential, the gas wasted by overheating can become appreciable.

In covering the consumption of natural gas on leases it might be well to examine gas powered pumps for injecting chemicals or circulating glycols, amines, etc., in process equipment. In most applications the gas used in driving these pumps is exhausted to the atmosphere and as such is usually nonrecoverable. The operators should watch these pumps very carefully to be certain that they are operated at the recommended rate. Over-pumping of an injection fluid can be costly principally due to the cost of excess fluid pumped unnecessarily and secondly due to the excess gas wasted. For the case of the circulating pumps excess fluid is not lost but additional heat is required in the reactivation process thereby creating a double loss of gas.

In conclusion it would be well to point out that no matter how well a unit has been designed, improperly trained or ill-advised operators can cause the unit to have poor operating performance in the field resulting in the loss of revenue through wasted gas.

Acknowledgment

This paper was presented at the eleventh annual Gas Technology Short Course held at Texas College of Arts and Industries at Kingsville, and sponsored by the Southern Gas Association, May 30-June 1, 1956. ★ ★ ★

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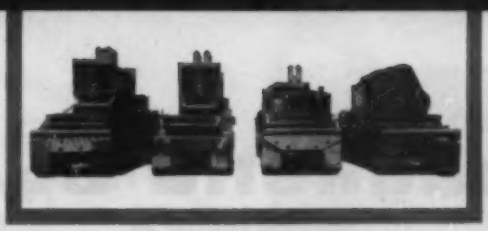

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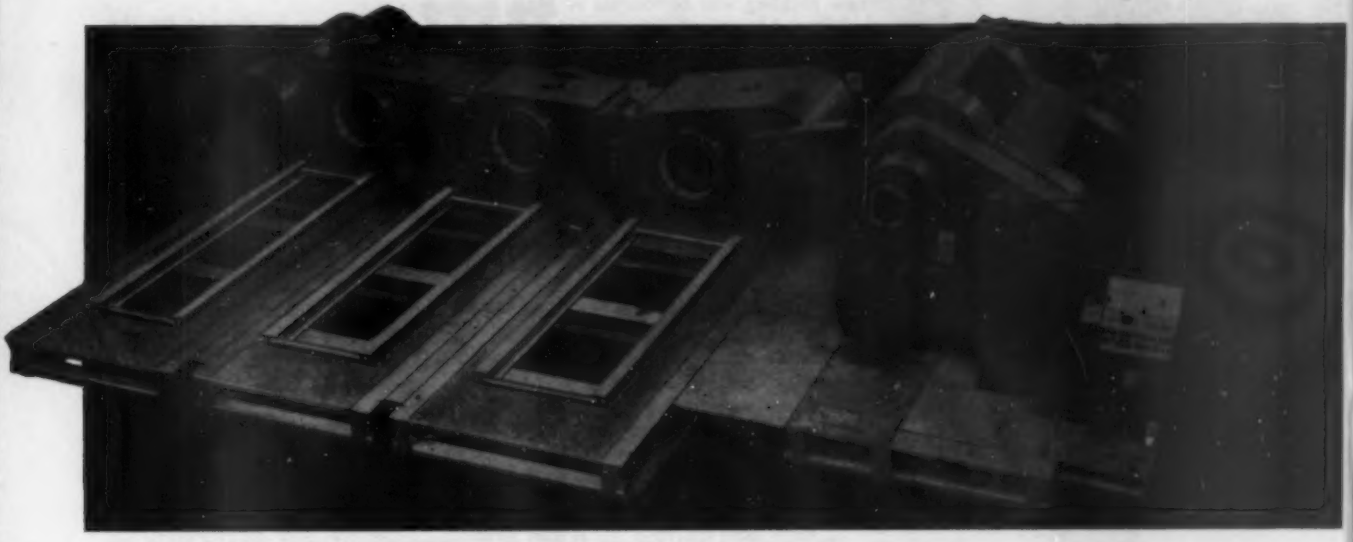

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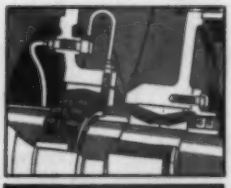

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Magnolia Begins Lab at Dallas Center

Unique record of the ceremonies was presented to Henry C. Cortes, Magnolia's vice president in charge of research, by Dr. D. I. Alexander, now manager of the laboratories following Dr. Clewell's transfer to New York. The record was a seismogram of the explosion.

CONSTRUCTION began on a laboratory building for Magnolia Petroleum Company, September 17. The new building will be located at Magnolia's field research laboratories near Dallas at Duncanville.

Specially designed for research purposes the one-story structure will house 21 separate laboratories and 34 offices. The field research lab's library and its digital computer — electronic brain — will be moved into the new building. The basement of the building will furnish space for an instruments shop, an electronics shop and a photography processing room.

According to Henry C. Cortes, Magnolia's vice president in charge of research, this addition to the Company's research facilities indicates the increased emphasis Magnolia is placing on research as an aid for finding and producing oil. The new building will provide room for new instruments and will replace small temporary buildings put up during World War II.

The building will contain 25,000 ft of floor space and will have temperature and humidity controls. The lower part of the outside wall will be brick and the upper part will be fluted aluminum.

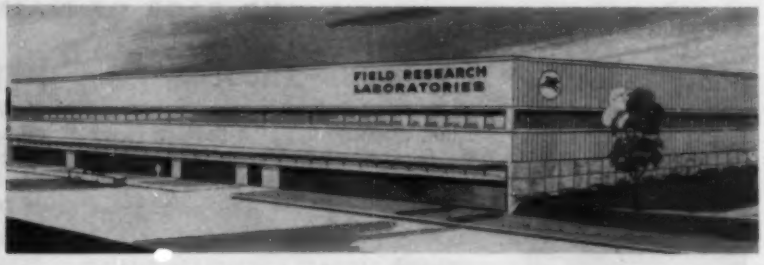
A second story is planned for the building within the next five years. The Austin Company is contractor and architect for the project. Completion of the building is expected in June next year.

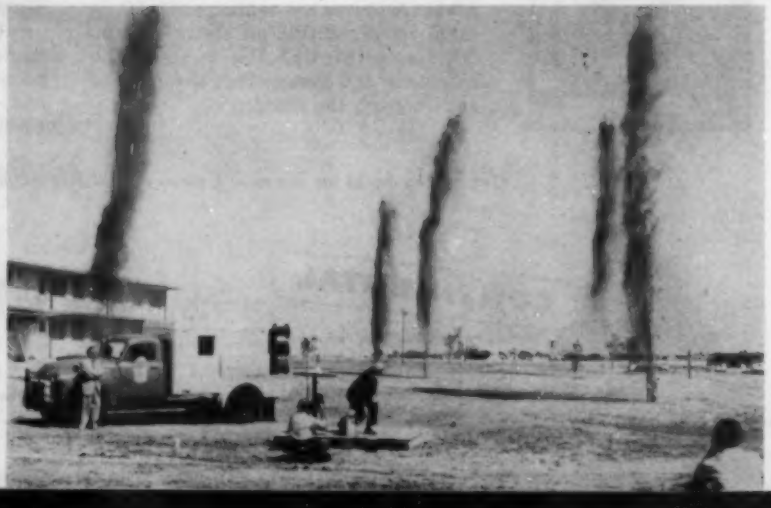
Sprays of dirt, rocks and water shot 40 ft into the air to put a modern touch to ground-breaking ceremonies for the new research building.

Forgetting the customary shovel, Magnolia's field research laboratories people placed small explosive charges used in seismic work at the corners of the foundation site. Vice President Cortes threw a switch from a seismic shooting truck, the blast signifying to company officers and lab employees that the building was formally under way.

Dr. D. H. Clewell, director of the Magnolia laboratories, officiated at the ceremonies. Cortes gave a short address following the breaking. ★ ★ ★

Dr. D. H. Clewell, former manager of the Magnolia field research laboratories, officiated at ground-breaking ceremonies for the new building in September.





Explosives set at the corners of the foundation site are detonated by Cortes, sending sprays of dirt and water 40 ft into the air.

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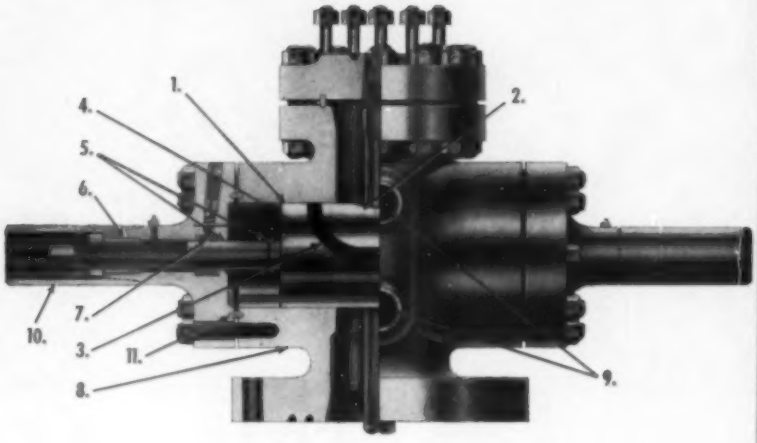

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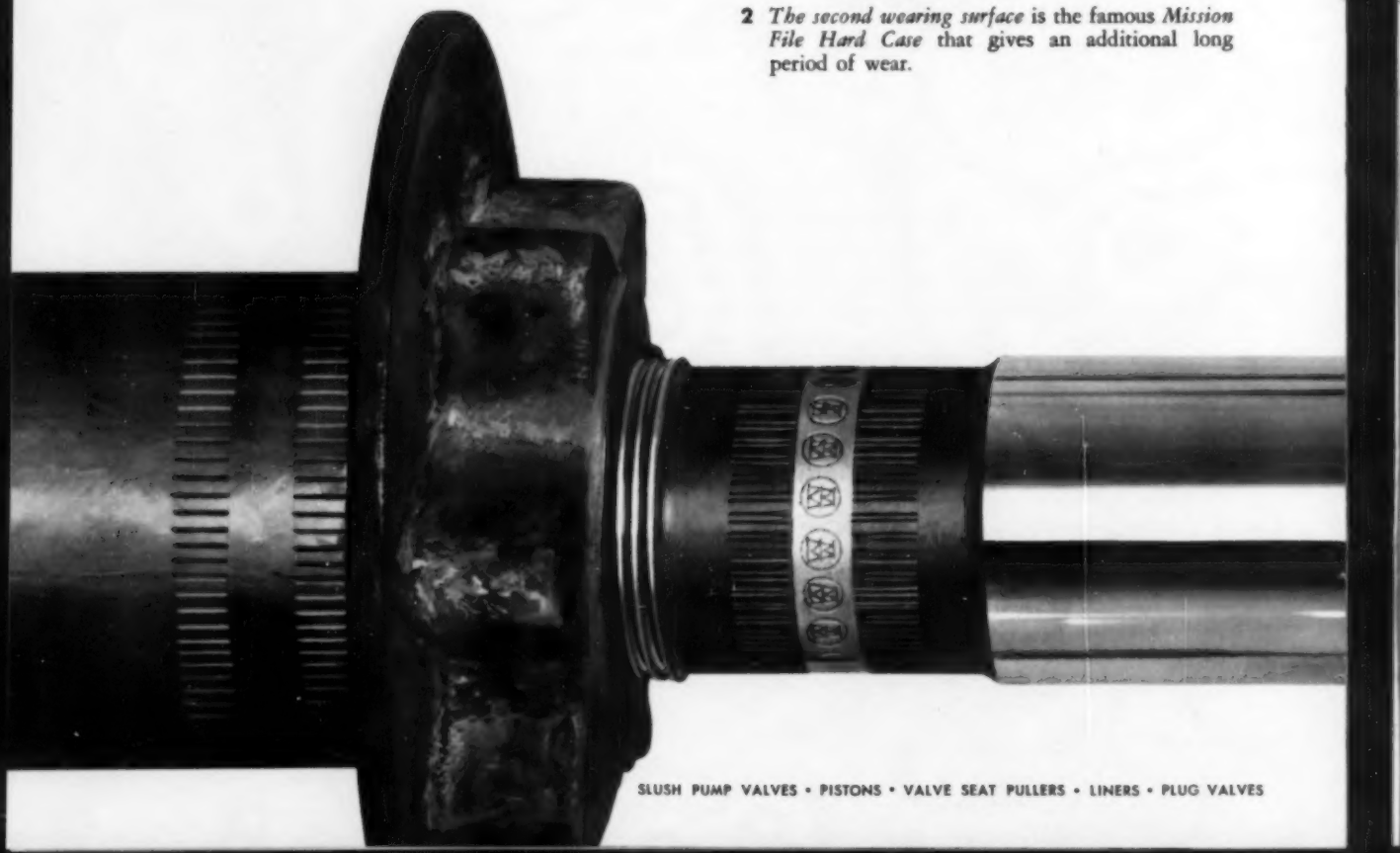

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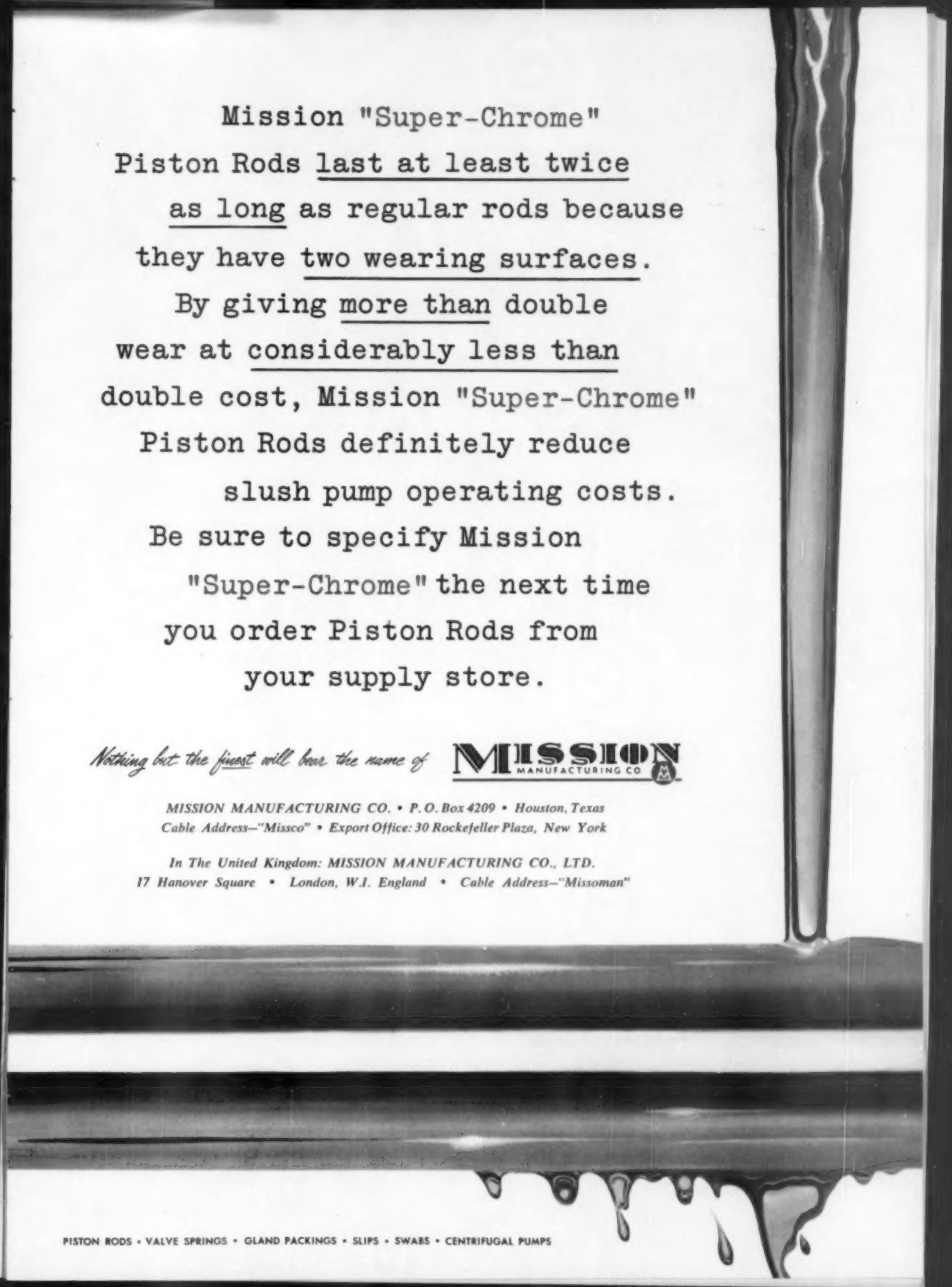

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THE OASIS—

A gathering spot for NOMADS

Eleven past-presidents of Nomads were present at the September 12 meeting of the Los Angeles Chapter, ten of the Los Angeles Chapter and one of the New York Chapter. Here they are: (seated) Joe Schlarb of Emsco Manufacturing Company; Bill Bettis of Johnston Testers; Harry Hester of McCullough Tool Company (present president); John Flanagan of Johnston Testers; Bill Wilson of Web Wilson Oil Tools; (standing) Russ McIntire of Baker Oil Tools (New York); Henry Pullman of Baker Oil Tools; Ernie Fowks of Emsco Manufacturing Company; Lee Laird of Laird Equipment & Sales Company. Not shown were Elmer Smith, Export Representative; Bob Eiche of R. J. Eiche & Associates; Fred Ripley of Oil Well Heating Systems.

Flanked on the left by Art Marshall of H. C. Smith Oil Tool Company and on the right by Bob Gaylord of Wagner Morehouse, Ritual Master, are three new members inducted into the Los Angeles Chapter of Nomads at the regular monthly meeting September 12. Left to right, Lloyd McGraw of Reed Roller Bit Company; Don Talmo of Johnston Testers; and Leroy Newcomb of Emsco Manufacturing Company.

New York Chapter of Nomads began its fall social season with a very successful party at the Hotel Roosevelt on Monday, October 1. A large and appreciative audience enjoyed a fine dinner and variety stage show. Among the group was an unusually large number of visitors. They are: (Seated) Glen Williams, Askins Stores, Inc.; R. W. Baldwin, Mene Grande Oil Company; Roy C. Allan, National Supply Company, Venezuela; R. S. Stephens, Mene Grande Oil Company; H. W. Mack, Mene Grande Oil Company; Monty Garrison, International Drilling Company, Italy; (standing) Forrest Penley, Tuboscope Company; R. E. James, Security Engineering Division, Dallas, Texas; A. C. Oden, McEvoy Company; C. E. "Pat" Olsen, Gearench Manufacturing Company; B. H. Pickard, Tuboscope Company; J. M. Fowler, A. C. F. Industries; D. W. McGee, Sahara Petroleum Company, and Judson D. Lowd, National Tank Company.

Foreign guests and speakers at the September 12 meeting of the Los Angeles Chapter of Nomads. Left to right (standing) Justin L. Holte of Mene Grande Oil Company from Venezuela; Jaime Reyes of Empresa Nacional from Chile; Sam Dodd of D. & E. from Brazil; Jack Robinson of Caltex from Sumatra; Gaither K. Whitley of Burmah Oil Company from India; Ronald Fuedge of Drilexco from Nigeria; Rosy Hendershot of Caltex from Sumatra; George H. Patterson of Aramco from Arabia; Robert E. Burns of American Independent from Kuwait: (seated) Kenneth L. Bourdo from Lebanon; R. L. Moore of Q. P. C. from Qator; Joe Atkins of Basrah Petroleum Company from Iraq; John C. Graffin, speaker of the evening; Mike Bush of Texas Company from Venezuela; (kneeling) O. S. Woodard of Drilexco from Brazil; P. Strobel of C.F.P.A. from Algeria; Sheyu S. Yang of Chinese Petroleum Corporation from Formosa.

Nomads Meeting Dates and Secretaries

New York Chapter, first Monday, of the month, Hotel Roosevelt, New York. Executive Secretary, E. W. Hoeppner, in care of Hughes Tool Co., Room 4414, 3 Rockefeller Plaza, New York 20, N. Y.

Houston Chapter, second Monday. Ye Olde College Inn, Houston, Texas. Executive Secretary, Harry E. Estes, P. O. Box 18161, Houston 23, Texas.

Los Angeles Chapter, second Wednesday, Jonathan Club, Los Angeles, California. Executive Secretary, W. A. Sawdon, P. O. Box 848, Hollywood 28, Calif.

Tulsa Chapter, third Friday, Mayo Hotel. Executive Secretary, E. L. Thomas, P. O. Box 4033, Tulsa, Okla.

Dallas-Fort Worth Chapter, first or second Monday. Secretary, H. A. Davis, H. A. Davis Power Equipment Company, 2142 Irving Boulevard, Dallas, Texas.

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ROPER Rotary Pumps

Sales and service in all oil producing areas

Guests of the Houston Nomads in October were G. W. Von Hillo, district superintendent with Shell Oil of Venezuela, and J. W. White, district superintendent, Sinclair Oil & Gas Company of Venezuela.

Houston Group Hears Franklin's Venezuela Report

Robert K. Franklin, President of Rolo Manufacturing Company and Chairman of the National Board of Regents, gave the principle address at the monthly meeting of the Houston Nomads. He outlined his trip to South America indicating that considerable more interest is being shown by oil companies in Nomad activities.

Three new Nomads were inducted into the chapter, filling the membership quota. They were, Ted Fullinwider, Domestic Oil Field Sales Manager, Mission Manufacturing Company, Sam Pearce, Camco, Inc., and Raleigh Hortenstine of Continental Supply Company.

Robert K. Franklin of Houston, left, chairman of the National Board of Regents of the National Oil-Equipment Manufacturers and Delegates Society and president of the Rolo Manufacturing Company, combined business and society duties in his recent trip to Venezuela. Here, he is briefed by Rafael Davila, Venezuelan consul general in Houston.

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There are good reasons for such acceptance. Every foot of CF&I Seamless Casing and Tubing is made under rigid quality controls to assure dependable service. And CF&I's mill at Pueblo, Colorado, is ideally located to give prompt, efficient service even on emergency rush orders. No wonder so many operators in the Denver-Julesburg Basin, and all over the West, depend upon CF&I Oil Country Goods!

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SEAMLESS TUBULAR PRODUCTS

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CF&I

Kermac Commissions Unique Drilling Barge

Cantilevered structure may be skidded longitudinally and transversely to fixed positions on grid-patterned hull to drill as many as six wells in 70 ft water

FIRST of two new identical offshore drilling units of goliath proportions is being completed for Kerr-McGee Oil Industries, Inc., in the yards of Ingalls Shipbuilding Corporation, Pascagoula, Mississippi.

Designated as Kermac Rig 46, the new deep water drilling barge is of a unique design. The barge hull is constructed in a grid pattern of tubular members 14 ft, 6 in. in diameter. The overall dimensions are 202 by 242 ft, with the working level 100 ft above the base line. The unit will be capable of operating in the open waters of the Gulf to depths of 70 ft.

Two box girder structural members extend outward 55 ft beyond the main platform and support the drilling substructure, mast, drawworks, rotary table, and other derrick floor equipment. By means of hydraulically operated rams, the entire cantilevered structure may be skidded longitudinally and transversely to fixed positions for multi-well drilling. Up to six wells may be drilled without re-locating the barge.

Kermac Rig 46 is powered by three 875 hp diesel-electric engines, each driving two 500 kw generators. The drilling rig is fully diesel electrical, and is adequate for drilling beyond present record depths.

Ample modern air-conditioned quarters for 50 persons are provided in a single level structural steel house containing 3600 sq ft of office, dining, sleeping, and recreation space. A helicopter landing port is located atop the quarters building.

Commissioning of Kermac Rig 46 was scheduled for late October, 1956. The rig is under long term contract to drill for a major offshore oil and gas producing company. It is expected to be placed in service about November 1, 1956.

Rig Structure

Stabilizing columns on the four corners are 22 ft in diameter for the lower 64 ft tapered to 5 ft in diameter in the upper 36 ft. There are also 20 support columns 42 in. in diameter and 2 support columns 48 in. in diameter. Stabilizing columns on the four corners extend approximately 6 in. below the bottom of the base barge.

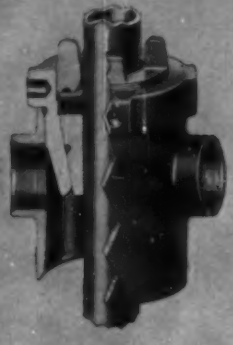
The Texas deck is 181 ft in width at its widest point and 228 ft, 6 in. in length at its longest point. The deck is "T" shaped with the crew quarters and engine housing on the cross-bar of the "T" and the drilling mast and drawworks located at the base of the "T." The cross bar of the "T" is 67 ft, 4 in. in width and the base of the "T" is 78 ft in width.

The mast and drawworks are located at the base of the "T" shaped upper deck. During normal well drilling operations the mast, drawworks, and their supporting substructure do not sit directly on the upper deck but are supported by two large beams cantilevered 55 ft beyond the edge of the deck.

HEAD OF THEIR CLASS

FIG. 91

Simplicity and compactness, for ease of installation and neatness of hook-up, are incorporated into the Larkin Casing Head (2000 psi test, 1000 psi working pressure.) It is designed to provide a safe and economical means of suspending and packing off casing strings. This head has been tested to support 225,000 lbs., equivalent to 5600' of 7", 20-lb. casing with a safety factor of 2.



TYPE L

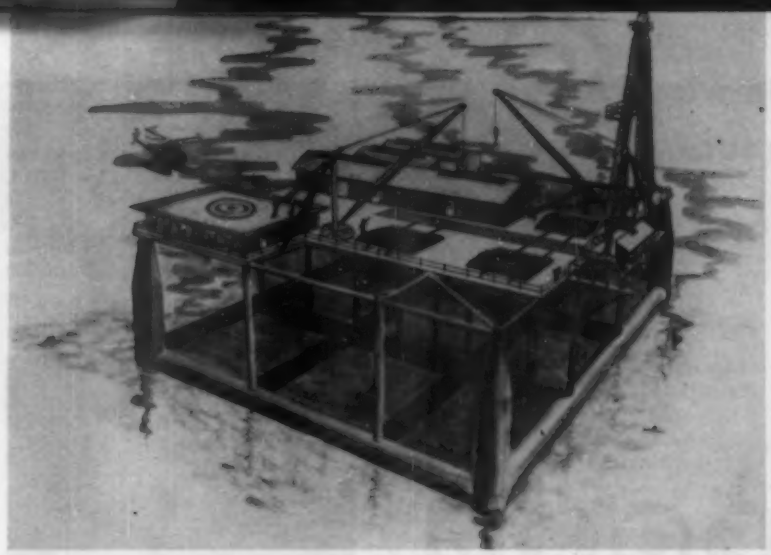
A new member of the Larkin Well Head line, the Type L Tubing Head fills a need in low pressure areas where economy may be effected with complete safety. It is forged steel construction, full opening, 2000 lb. psi, top of body threaded 7" API to accommodate control equipment, hinged three-segment slips, 2" or 3" side outlets.

For detailed information on these and other Larkin Tubing and Casing Heads, please refer to your Larkin Catalog or talk to your Larkin Representative. All Larkin Equipment is available through your supply store.

LARKIN LEADERSHIP HAS BEEN EARNED

B-146

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD



This mast supporting substructure is a two-piece affair consisting of a 14 ft high truss-type lower section and 3 ft deep girder type upper structure. The truss-type lower structure spans the 46 ft between the two aforementioned cantilevered beams. The upper structure is designed so that it can be skidded to different locations on the lower structure. Thus, by skidding one structure on the other, or both on the cantilever beams, it is possible to drill as many as six wells before it is necessary to move the entire barge. Overall height of the barge, the mast and mast substructure is 268 ft.

Base barge storage provides for 3950 bbl of drill water, 780 bbl of potable water and 780 bbl of fuel oil. Liquid mud capacity is 800 bbl.

Equipment:

Complementing the three diesel-electric engines is an auxiliary generating system consisting of two 500-hp engines, each driving a 350 kw 440 v a-c generator. All engines are keel cooled.

Two mud pumps, each powered by two 625-hp electric motors, and one smaller electrically powered pump for mud mixing services are used.

A double drum drawworks with 1600-hp rating is driven by two 625-hp unitized motors; 27½ in. rotary table is independently driven by one 625-hp motor.

Drilling mast is 151 ft high with 30 ft base with 750,000 lb hook capacity and 130 mph wind capacity. Mast is so designed so it can be used as a construction boom for setting well protection platforms. The capacity of the mast when used as a construction boom is 125 tons.

Bulk mud weight material is stored in one 2400 cu ft bin with additional space on the deck for storage of upwards of 5000 sacks of mud in 50 sack skip buckets. In addition to the weight material storage described above, there is a 37 by 50 ft room for sack storage of cement and other mud additives.

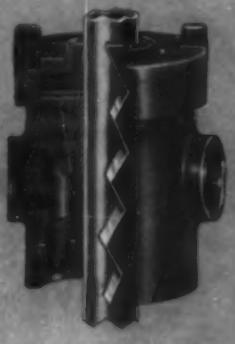
Material handling equipment includes two stiff-leg derricks with maximum reach 105 ft and a fork-lift truck for handling materials in the enclosed areas.

The rig also includes a cementing unit and electric logging unit. ★ ★ ★

for medium pressure wells

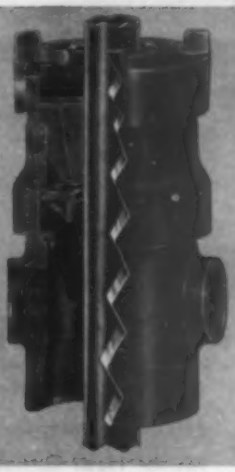
TYPE R

The Larkin Type R. Tubing Head is a conversion from the Type SR Head. This ease of conversion makes it possible to use the same stripper adapter and Neoprene stripper when working on any well equipped with a Larkin Tubing Head.



TYPE SR

The Larkin Type SR Tubing Head is a slip suspension head, equipped with a Neoprene Stripper which serves as a blow-out preventer and oil saver while tubing is being pulled or run. It is very suitable where higher pressures might be encountered.



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BY YEARS OF DEPENDABLE PERFORMANCE

Douglas, Jackson Spark IPAA's Twenty-seventh Annual Meet

Canadian oil industry, oil and gas taxation discussed at Dallas convention

The premier of Saskatchewan and a prominent Texas oil and gas tax authority were among speakers scheduled to address the twenty-seventh annual meeting of the Independent Petroleum Association of America in Dallas, Texas, Oct. 29-30.

Premier T. C. Douglas discussed the Canadian oil industry, with emphasis on Saskatchewan, at the two-day meeting in the Statler Hilton Hotel. In connection with his talk on oil in Canada, IPPA's Western Hemisphere Oil Study Committee reported to the membership at the same session, Chairman J. R. Butler of Houston speaking for the committee.

J. Paul Jackson of Dallas discussed "Some Recent Developments in Oil and Gas Taxation." Jackson, who has lectured at various institutes throughout the country on oil and gas taxation, and has been a lecturer on taxation in the Law School at Southern Methodist University, is a member of a Dallas law firm.

Jackson's address followed the report of IPAA's Tax Study Committee, delivered by Chairman L. J. O'Connor, Jr., of Houston.

In addition to Jackson, Premier Douglas and other principal speakers, oilmen at the meeting also heard reports by IPAA President Robert L. Wood and by Russell B. Brown, general counsel for IPAA in Washington.

T. C. Douglas

Paul Jackson

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Every day, earth mover, truck, tractor, grader, shovel, crane, dozer, oil field and power unit operators are establishing NEW on-the-job RECORDS with MORLIFE* CLUTCH equipped machines. They report more continuous hours of heavy-duty, off-highway work, with fewer clutch adjustments, than ever before. Some of the latest records will be featured in the Rockford Clutch booth at the Road Show in Chicago.

New MORLIFE* CLUTCHES and CLUTCH PLATES Give-

MORE Clutch Life (400% MORE)

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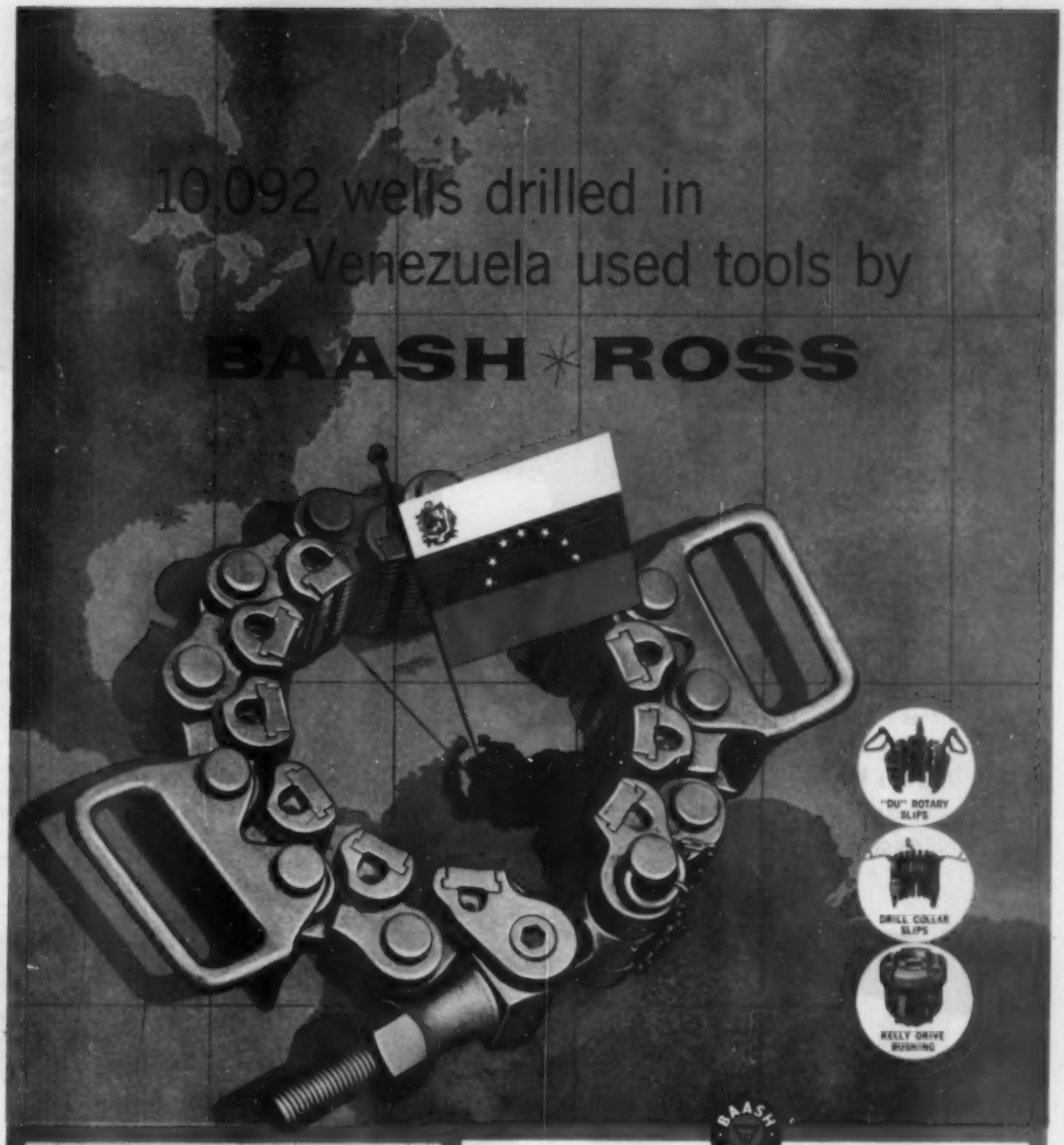
CLUTCHES



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Very wide range of sizes by adding or taking out links.

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When you use Baash-Ross Safety Clamps you get positive protection against many costly fishing jobs by preventing flush joint equipment from dropping into the hole. B-R's many exclusive features have paid off on over one million wells. Let them pay off for you.

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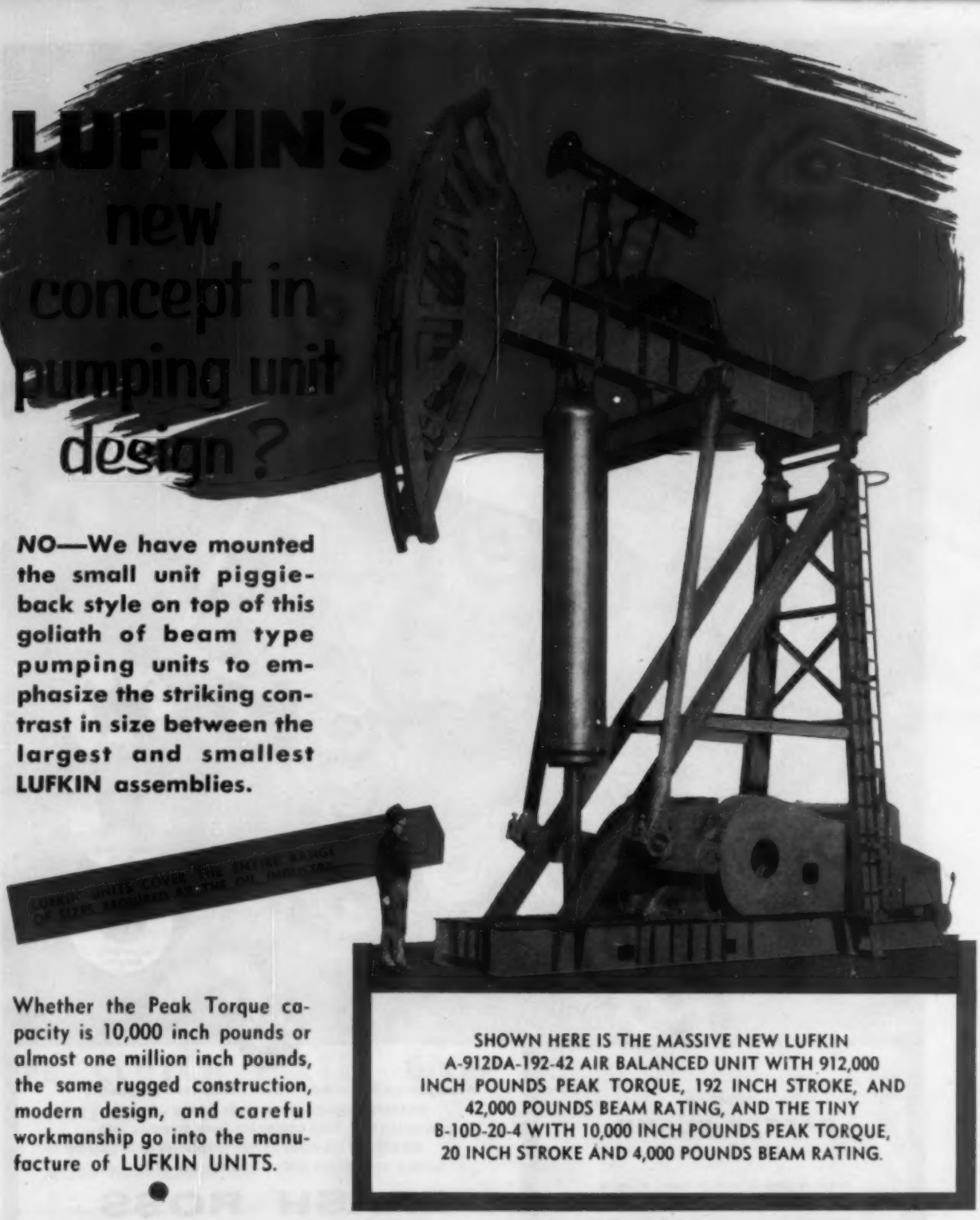
For further information write P.O. Box 1348, Houston 1, Texas or see The Composite Catalog.

LUFKIN'S new concept in pumping unit design?



NO—We have mounted the small unit piggie-back style on top of this goliath of beam type pumping units to emphasize the striking contrast in size between the largest and smallest LUFKIN assemblies.

Whether the Peak Torque capacity is 10,000 inch pounds or almost one million inch pounds, the same rugged construction, modern design, and careful workmanship go into the manufacture of LUFKIN UNITS.

SHOWN HERE IS THE MASSIVE NEW LUFKIN A-912DA-192-42 AIR BALANCED UNIT WITH 912,000 INCH POUNDS PEAK TORQUE, 192 INCH STROKE, AND 42,000 POUNDS BEAM RATING, AND THE TINY B-10D-20-4 WITH 10,000 INCH POUNDS PEAK TORQUE, 20 INCH STROKE AND 4,000 POUNDS BEAM RATING.

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Petroleum Industry's First Offshore Microwave System

THE petroleum industry's first offshore microwave radio relay system will be constructed this year for the Magnolia Petroleum Company, Dallas, Texas.

The offshore system is being installed by Radio Corporation of America to provide communication for coordination of the company's production and pipe line operations in the Gulf of Mexico, off Morgan City, Louisiana. Microwave has been selected as the communications medium because of the crowded VHF radio conditions in the area, and because it assures privacy and provides facilities for such additional services as telemetering and equipment control.

The five-station, four-hop RCA microwave system will span a distance of more than 75 miles and provide approximately 55 miles of over-water communication to link Magnolia oil fields in the Gulf with the company's operations headquarters at Morgan City.

Construction of the system is expected to get underway soon, and is scheduled for completion by the end of this year. The microwave system will utilize RCA CW-20 equipment, operating in the 2000 megacycle band, and will have a capacity of 30 channels. Service will be initiated with three channels, two for voice communication, the third for VHF radio communcation.

The system will extend from Morgan City to Burns Terminal, 19 miles away, then 24 miles out into the Gulf of Mexico to Magnolia's Block 51 oil field. From Block 51, the system will extend 23 miles to Block 126 and on to Block 128, about nine miles away.

A feature of the installation will be the use of two parabolic antenna dishes on antenna towers, providing diversity reception to offset the possibility of signal fading inherent in over-water communcation. One dish will be mounted atop the antenna tower, the other approximately 70 ft lower. * *

Offshore microwave radio relay system to be constructed this year for Magnolia Petroleum Company, will provide communication for coordination of company's production and pipe line operations in Gulf of Mexico, off Morgan City, Louisiana. As shown above, the system, covering distance of more than 75 miles, will provide 55 miles of over-water communication.

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Performance Records show . . .

- More Footage
- Lower Costs
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because pumping with REDA lowers costs and INCREASES PROFITS!
HERE'S HOW:
- Large water volume obtained from smaller size well casings reducing number of supply wells necessary
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Reda Submergible Pumps are a major factor in the success of waterflooding and pressure maintenance operations. They are being used in major floods with very successful results of increased production and lowered costs.

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Gulf Research licenses device for industry-wide use; conservation of drilling fluids, rig time and producing zones

Leak Detector Developed to Find Lost Circulation Zones

GULF Research & Development Company has developed an instrument that successfully locates borehole leaks in drilling wells. The invention is expected to mean the savings of millions of dollars yearly to the petroleum industry.

To drillers, it forecasts the end of the 50-year-old nightmare that has bedevilled wildcat operations in particular ever since the rotary drill rig came in at the turn of the century.

Gulf has licensed the new "oil well leak detector" to service organizations which will make it available to the industry at large.

Importance of the detector lies in halting the loss of drilling mud through apertures in the drillhole wall commonly referred to as "lost circulation" or "lost returns." Such apertures may be pre-existent as in the case of porous limestone rocks or they may be produced by rupture of the formations during drilling.

The invention does what amounts to 75 per cent of the job of plugging leaks which threaten this essential well fluid, Gulf claims. Namely, it pinpoints the thief area within six inches, and under all well conditions, by electronically recording the change in rate and direction of mud flow at the leak orifice.

Once the location is known, pipe can be positioned in the well so as to pump plugging agents right onto the leak, closing it effectively, quickly, and cheaply.

This approach means the difference between plugging the aperture direct — or treating the entire length of the hole, which may extend for a half to more than three miles, with sealing matter.

Since leaks now and then occur in productive formations, an oil pay zone is sealed off from production during indiscriminate efforts to arrest loss of circulation. Location of the zone of loss followed by testing might lead to the discovery of a new oil field which otherwise would not be detected.

Numerous methods of leak location have been tried, including radioactive, thermal and mechanical. The former two sometimes proved too narrow in application or inconclusive, while the mechanical instruments tended to clog due to sealing materials in the mud stream.

The new solution, involves the use of a hollow cylinder, narrowed at its lower end, with an opening, or window, in the side. Across part of the window is fastened a flexible membrane containing an electrode. The device is lowered down the leaking well at the end of a cable while drilling mud is pumped down through it.

Because of the cylinder's narrow lower end, some of the descending mud is forced out through the window, exerting pressure on the mem-

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brane there. The moment the detector passes below the lead, however, the flow of mud is diverted — running off into the aperture instead of through the instrument.

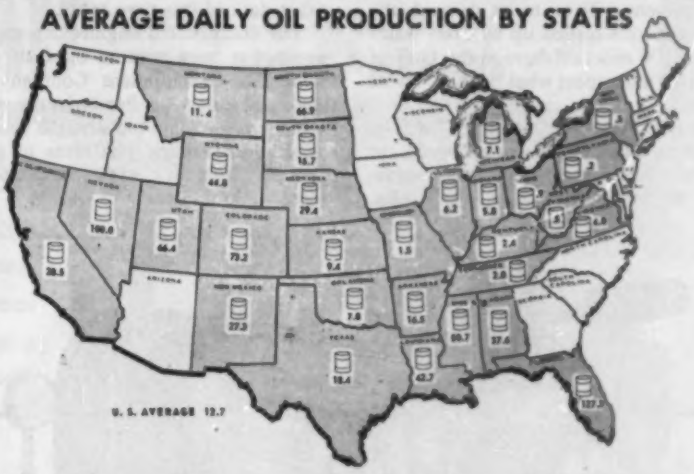
As a result, pressure relaxes on the membrane, which moves back to normal position. This reaction, which is electronically recorded at the wellhead, signals the exact location of the thief zone.

Sensitivity of the device is said to be such that it records the drop in mud velocity occurring below crevices or porous leaks drawing off as little as half a barrel of mud per minute. The instrument is extremely difficult to clog; and, should materials stick in it, they can readily be broken free by manipulation. Time consumed in using it to survey a well for a leak averages about one hour.

One major discovery of the instrument, says Gulf, is that conventional estimates of where circulation losses occur have been inaccurate. It was generally assumed that leak locations coincide with the point where the drill bit was operating when the loss was observed. The detector shows, however, that in the case of losses of the pressure-induced variety, 90 per cent of leaks occur at some distance above the drill position and not infrequently several thousand feet from the hole bottom.

The petroleum industry appears likely to suffer only one loss because of the "leak detector." This concerns the strictly imaginary story that an asylum exists in the Texas Panhandle for drillers who have been driven out of their heads by "lost circulation" troubles. This mythical institution may now have to close its doors. ★ ★ ★

AVERAGE DAILY OIL PRODUCTION BY STATES



OIL WELL PERFORMANCE — The above chart shows that U. S. oil wells do not produce large amounts of oil. In Pennsylvania, for instance, there are 78,500 wells producing oil, yet the average production per well is only two-tenths of one barrel per day. The other extreme is Florida, with only 11 wells, producing 127.3 barrels of oil per well per day. The daily average for the more than a half-million wells in 29 states is only 12.7 barrels per well. *(Source: Independent Petroleum Association of America.)*

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with
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Write for bulletin 53

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Hurricane Inspector Created by Gulf Oil

A robot "hurricane inspector" is being built by Gulf Oil Corporation. Its assignment will be to sit through the worst storms dished up by open water up to 100 miles offshore in the Gulf of Mexico and report what happens inside them.

It is believed the "inspector" will be the first, either human or electronic, in marine history to scientifically measure the forces of waves, winds, tides, and currents in the open sea and in water depths over 100 ft. Almost no exact data of this type exists.

The complicated engineering mechanism has been created by Gulf Research & Development Company at nearby Harmarville, Pennsylvania, with the aim of learning the strength needed in offshore drilling platforms to protect the operating crews and equipment.

The design of these platforms is based now on the "hind-casting" method, developed during World War II to gage beach landings. "Hind-casting" calculates future storm violence from past observations correlated with theoretical maximum sea forces in relation to the depth and exposure of particular areas.

While considered fairly reliable, no one knows for sure to what degree and in what direction "hind-casting" may differ from actual fact.

So a lot of treasured sea legends — and perhaps scientific theories, too — may go by the board when the "hurricane inspector" starts turning in its reports.

Not new in the sense of being developed from the ground up by Gulf, the "inspector" is a complicated adaptation of existing instruments. The problem was to unite them into a compact unit which would record and correlate many types of information.

Two heavy-steel, water-tight boxes, one about the size of a small household refrigerator and the other slightly smaller make up the unit. The whole is self-operated by a battery continually re-charged by a wind generator. Moisture absorbers are included to keep the delicate instruments damp-free.

The boxes contain amplifiers, power units, connecting cables, sequence timer, timing marker, and two recorders for imprinting six channels of information on running chart paper correlated with the date, hour, and minute. Recordings will be automatically taken for two minutes each half hour.

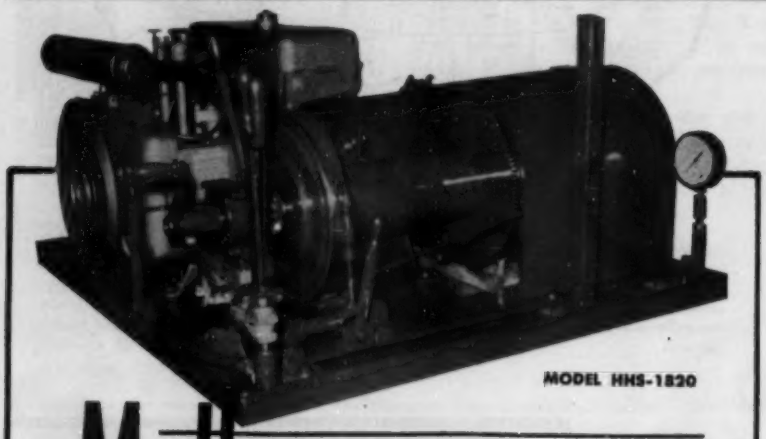
The "inspector" will record the height of waves, period between crests, and the tide during their occurrence. From this data wave length and velocity can be computed. A "wave profile recorder," in which insulated spark plugs momentarily short out as a wave passes over, will do the measuring.

Wind velocities will be noted by a wind velocity-wind direction indicator up to 100 mph. Above that a wind gust indicator will take over.

Wave and current forces will be measured by two steel tube piles, one smaller than and standing inside the other. The outer pile will absorb the force, and the inner unaffected one will give a comparison. Electric strain gages transmit the data.

Present drill platforms are built 40 ft above mean water level based on "hind-casting," and about the deepest water any stand in so far is 125 ft.

* * *



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EXPLORATION ACTIVITIES

TEXAS

★ Seminole Oil and Gas Corporation has spudded a 13,000 ft test in Crane County. Working with Shell Oil Company, Seminole will drill on the Seminole-W. P. Edwards lease, on a 763 acre tract in Block 23 in the Edwards pool. Operators will test several major zones recently discovered in the area.

★ Carter-Jones Drilling Company, Kilgore, Texas, has dually completed the No. 1 Hoskins to open a new Atoka conglomerate pay area in Wise County. The discovery well, two miles west of Chico, potentialed 1088 bbl per day from two zones. During an 8-hour test, the well flowed 153½ bbl of 41.4 deg oil through a 24/64-in. choke from the Atoka perforated at 5651-5657 ft for a calculated 24-hour yield of 460½ bbl. Gas-oil ratio was 896 to 1. Second formation being produced from the Hoskins well is the Caddo conglomerate. It is the second well producing from this formation in the Becknall field. Flow recorded was 314 bbl of 40 deg crude in 12 hours through a 24/64-in. choke from perforations at 5323-5346 ft for a daily potential of 628 bbl. Gas-oil ratio was 516 to 1. Total depth of the well was 5833 ft.

★ Fletcher Oil & Gas Drilling Corporation is stepping up its North Texas program as the result of a good Bryson sand find in Clay County. The company's No. 1 J. M. Hatfield, 2 miles southwest of Jolly, registered a 24-hour potential flow of 247 bbl through a 16/64-in. choke from perforations at 4927-35 ft. Gas-oil ratio was 550 to 1. Bryson was topped at 4912 ft. The opener is more than two miles north and west of the Ross field. Discovery allowable has been requested.

★ Significant Pennsylvania reef discovery has been completed by Seaboard Oil Company northwest of Lamesa in Dawson County. The well is the No. 1-A J. R. Weaver, 2½ miles southeast of Mungerville. Reef was topped at 8963 ft and 134 ft of reef pay was logged prior to the last drillstem test, which brought water. First gage recorded a flow of 170½ bbl of oil in 10½ hours. First two hours of the flow was through a 24/64-in. choke and the remainder through a 14/64-in. choke. Nearest production is in the Wells Devonian pool, about five miles away.

★ Another confirmation attempt is being made by British American Oil Producing Company to supplement its Woodbind discovery in Wood County. The new venture is the No. 1-B Bessie Weisenhunt and is slated to drill to 10,500 ft into the Woodbine. Discovery and lone producing well No. 1 Weisenhunt is on the flank of the Hainesville salt dome 6½ miles northeast of Mineola. First confirmation try was the No. 1 Victoria Warlick, which was drilled to 5510 ft and abandoned.

★ Confirmation has been established to the discovery well in a new Yegua oil pool in Bee County, in the southwestern part of the state. Both the discovery and the follow-up well were drilled by Hillcrest Oil Company, Chiles Drilling Company and Sid Katz. Discovery was the No. 1 Emma Holzmark, which gaged only 17 bbl of oil from perforations at 4127 ft with a gas-oil ratio of 11,888 to 1. Second well, just completed, is the No. 1 B. F. Voss which came in flowing 97½ bbl of 48.4 deg oil daily through a ⅛-in. Halzmark choke and perforations at 4141 ft. Gas-oil ratio was 447 to 1. This well is 660 ft northwest of the initial well. The new pool has been named the Holzmark field.

KANSAS

★ Cities Service has staked for drilling its wholly-owned Gibson "B" No. 1 as a test well in the center NE NE NW, Sec. 17-22s-7e, Chase County. Located approximately 23 miles northeast of El Dorado, Kansas, the test is in the East Wonsevu block. Cities Service holds leases on 10,240 acres in the area. The test is to be drilled to a depth of 2850 ft and will have the Mississippian formation as objective. Nearest production is from the Florence pool, approximately 12 miles to the northwest.

★ A Morrow gas field has been opened by Panhandle Eastern Pipeline about two miles southeast of the Richfield townsite in Morton County. Well is the No. 1 Going, in SE of 26-32c-41w, which tested 97,000,000 cu ft of gas a day on state potential test. Productive zone is from 5192 to 5222 ft.

BAHAMAS

★ Bahama Islands offshore exploration has been approved for Bahama National Oil Company, Ltd., a subsidiary of National Oil Company. The firm has been granted exploration rights to more than 5,000,000 acres of submerged lands and offshore oil properties. Company officials report that an exploration contract has been signed with a major company to evaluate the grant. This program marks the first time that the company has expanded its operations outside California.

NEW MEXICO

★ A significant Strawn discovery is indicated at the Cities Service State AX No. 1 test in Lea County. On a drillstem test of the Shawn between 10,950 to 10,991 ft, the well flowed at the daily rate of approximately 1560 bbl. The 24-hour rate was based on a four hour and 14 minute flow during which the well produced 277 bbl of 46 deg oil. Test was through a 1-in. top choke and ⅝-in. bottom choke. Flowing tubing pressure was 1190 psi. The test is located approximately 13 miles southwest of Lovington, on a 1280-acre unit. Cities Service also has approximately 1000 additional acres in the vicinity. Location is SE NE, Sec. 14-18s-35e, Lea County. Cities Service holds slightly more than 50 per cent interest in the test, with remaining interest held by Gulf, Shell, Pure and Superior.

CALIFORNIA

★ Union Oil Company and Hancock Oil Company today announced completion of a discovery well in the San Joaquin Valley about 8 miles southeast of Bakersfield flowing 27.4 deg oil at a rate of 1170 bbl a day with 800,000 cu ft of gas. The two companies have a block of 4450 acres surrounding the discovery location. Union, with a 75 per cent interest, is acting as operator of the joint venture. The wildcat, Stendrup 55X-21, was drilled to a total depth of 12,514 ft. The producing interval in sand equivalent to the Derby sand, is from 9535 to 9717 ft.

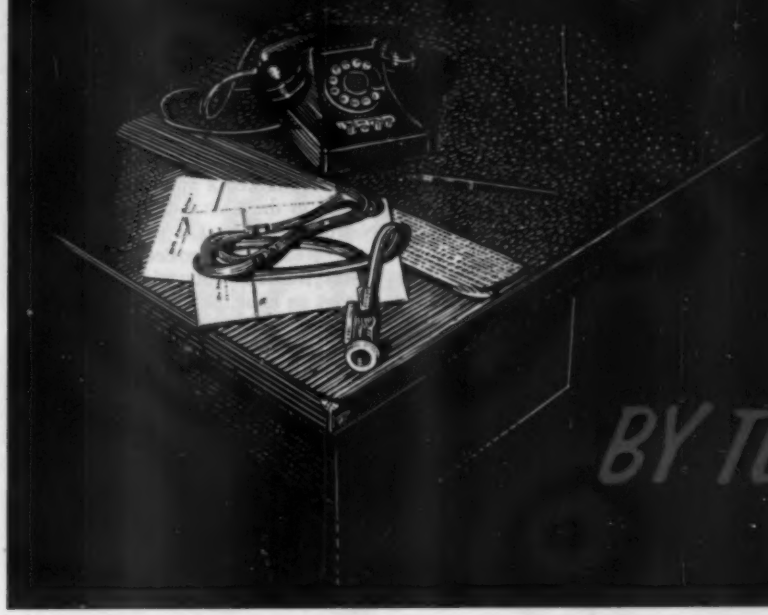
LOUISIANA

★ The CATC Group has completed an offshore wildcat oil well in the West Delta area off the coast of Plaquemines Parish. Well, the State 987 No. 2, flowed at a daily potential rate of 266 bbl of 30.6 deg oil through a 9/64-in. choke from perforations in the Miocene at 10,152-66 ft. Tubing pressure was 1600 psi. Total depth of the well is 11,029 ft.

COLOMBIA

★ New concessions on some 670,000 acres in the Magdalena Valley area have been granted to International Petroleum Company, a subsidiary of Jersey Standard. International is starting a well near Bogota and the Texas Company is drilling a wildcat south of the capital city. Other active American firms in the country are Richmond Oil, Cities Service, Socony Mobil and Forest Oil companies.

you wouldn't ask for a medical check-up . . .



BY TELEPHONE

As scientific as our modern system of communications is, it has certain limitations. For example, a medical check-up by telephone would be a risky substitute for a direct physical examination in the doctor's office.

Each formation evaluation technique has its proper time and place, too.

For example, tangible "down-to-earth" reservoir information starts with a direct surface analysis of the basic product — the formation and its contents. Then, from these virgin data which accurately determine the physical make-up and productive potentialities of the formation, the proper choice and effective application of various types of down-hole electronical and mechanical tests can be made.

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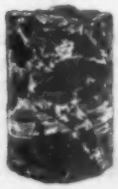

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Exploration

GUATEMALA

★ Continental Oil Company of Guatemala has been granted oil rights on 394,000 acres in the northern sector. The concession, following closely other grants made to Ohio Oil and Amerada Petroleum, will be combined to form a single unit, with all acreage under the supervision of one operator. Preliminary exploration work has already been completed on the concession, say Conoco spokesmen, and additional exploration operations will begin immediately. As yet no wells have been drilled in Guatemala.

UTAH

★ Large oil discovery has been completed in San Juan County by The Texas Company. The find is a Paradox zone discovery, the No. 1 Navajo-J, in C NE NE of 20-40s-26e, 10 miles east of Aneth field. Well potentialed 1420 bbl of oil with gas-oil ratio of 1051 to 1 on chokes, producing from perforations at 5585-5625 ft. Texaco drilled to 5833 ft and set casing at 5817 ft. Aneth field now spreads about 18 miles east and west.

COLORADO

★ British American Oil Producing Company is completing its No. 2-B Reiners in the Denver-Julesburg Basin. Well is 1½ miles west of the Armstrong gas field in Logan County. On drillstem test in the "J" sand at 5300-328 ft, the well flowed 40 bbl of oil and 3 bbl of fluid in 40 minutes. A second test in the same zone yielded a blow of gas and 5 bbl of drilling fluid in 10 minutes. Hole was bottomed at 5380 ft; casing was set to bottom.

★ Shawnee Oil Company, Sunray Mid-Continent Oil Company, et al, were completed initial production tests on their discovery well in C NW SW Section 29-10N-53W, Logan County. Following acidizing and sand fracturing of perforations in the "D" sand, 4816 to 4822 ft, the well kicked off and flowed 30 bbl of oil per hour with no water. It is shut in awaiting erection of tank batteries.

MONTANA

★ Joint venture of Stanolind Oil & Gas and Gulf Oil has two major wildcats working in the Disturbed Belt in the northwestern part of the state. The team's No. 1 Blackfeet-Federal is spotted just south of the Canadian line, six miles northwest of Bagg in Glacier County. This well is slated to go to 13,000 ft. Second test is the No. 1 Gelsinger, six miles south of August in Lewis and Clark County. It will be drilled to a depth of 9500 ft or to the Madison.

WYOMING

★ A new field has been opened at Delta Drilling Arrowhead Exploration and Argo Oil's No. 1 Government. Discovery is located 3½ miles southeast of the Grieve field in Natrona County. Wildcat swabbed 156 bbl of oil per day from a fractured zone at 6109-21 ft. It is shut in to install surface equipment.

★ Sinclair Oil & Gas, et al, completion of the No. 8 East Salt Creek unit well has marked a new deep zone discovery in the East Salt Creek pool of Natrona County. The pay opener was completed in the Tensleep sand of the Pennsylvanian. It flowed 81 bbl of 31.8 deg oil an hour for 12 hours from perforations at 7542-570 ft for a calculated potential of 1944 bbl of oil per day. Well was drilled to 8300 ft in the Madison, cased to 7918 ft and plugged back to 7835 ft. East Salt Creek pool has been producing from the shallower Wall Creek and Lakota sands of Cretaceous age. Minority owners in the discovery well are Kenilind Oil & Gas Company, Isbrandtsen Company, and Baruch Oil Corporation.

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What's doing in DRILLING

★ **"Back to work" order** has been given to Louisiana offshore drillers as a result of successful state and federal government negotiations in the offshore ownership campaign. Operators and contractors are already on the move. Humble, which has had 10 of its 16 rigs idled during the restraining order, expects to be back in full operation by early January. Magnolia-Continental-Newmont offshore group reports that it will be ready to get back to work as soon as it can get permits. This group has had four rigs tied up on shore and six more doing remedial work. Of the 84 rigs operating off the Louisiana coast before the shutdown, about half have ceased operations.

★ **Anderson-Prichard Oil Corporation** received initial permit to resume drilling in disputed Louisiana waters. Permit was granted jointly by the U. S. Geological Survey of the Department of the Interior and the Louisiana Department of Conservation. Apco was allowed its permit first since it held dual leases — leases on the same tracts from both the state and federal governments. As a result, the company already had its application for a drilling permit prepared and lacked only the signatures of officials for approval.

★ **Zach Brooks Drilling Company** has completed the forty-third producer in Alabama's new Citronelle field. Latest well, the No. 1 Onderdonk, swabbed 60 bbl per day of 41 deg oil. Last completion is the southernmost location in the field, three miles south of the Donovan discovery well on the northern outskirts of the town of Citronelle.

★ **Russia is using larger offshore** platforms and is drilling deeper exploratory wells in an effort to increase oil production from Caspian Sea fields near Baku. While some wells have been drilled as far as nine miles from shore and to depths of about 13,500 ft, newer platforms are being developed, the Russians assert. Work is progressing on an offshore steel platform in the Neftyaniye Kamny field from which 16 directional wells will be drilled. Water depth at the location is about 66 ft. Platforms and derrick construction now account for "up to 80 per cent" of the entire cost of Caspian Sea wells, compared with 6 to 18 per cent for onshore wells.

★ **New offices** are being opened in Oklahoma City, Oklahoma, by Garvey Drilling Company. Garvey, with home offices in Great Bend, Kansas, is operating two large rigs in Garfield County and Texas County, Oklahoma. Neal Colby is being transferred from Great Bend to take charge of the new office.

★ **First wildcat** to be drilled in Turkey with foreign capital is well under way by Gilliland Oil Corporation, S. A. The test is in the Adana Basin on the shore of the Mediterranean Sea in Iskenderun Gulf, southwest of Ankara and northeast of the island of Cyprus. Drilling and Exploration Company of Delaware is drilling the well directionally to offshore horizons in the Pliocene, Miocene, and Eocene ages. Gilliland owns rights totalling 250,000 acres in Adana Basin and along the eastern side of the Tigris River, north of Iraq border, and will drill in this area next year. The Tigris River location is about 30 miles from present Iraq oil fields.

★ **Pressure control equipment** is being flown to Iran's lush 80,000 bbl per day gusher. The well, owned by the National Iranian Oil Company, was drilled by Drilling and Exploration Company of Delaware. At last report drill pipe was still in the hole, following the well's uncontrolled two-week tirade when the bit broke out of shale and entered a porous limestone formation at 7800 ft. About 6000 ft of 9⅝-in. casing had been set and all of the couplings are reported intact. Experts plan to snub in a pack-off overshot so that weighted-up mud can be circulated and the well killed.

★ **Drilling operations ceased** in mid-October at Pakistan Petroleum Limited's No. 2 Sylhet, important test well in Pakistan. Natural gas was encountered below 4000 ft and drilled to a total depth of 9245 ft to evaluate deeper formations. Drilling ceased because of high pressures encountered.

★ **Wilson Garrison** becomes sole owner of Garrison-Begert Drilling Corporation, Princeton, Indiana, following purchase of interest held by his partner, C. C. Begert. Garrison is reorganizing and has changed the firm name to Garrison Drilling Corporation.

★ **Eighteen of 45 wildcats** drilled this year by Standard Oil Company of California have been successfully completed as new fields or new pay discoveries. The announcement was made recently by R. G. Follis, board chairman. The Stancal record is double the 1955 national average ratio.

★ **Wanette Drilling Company** has been formed in Oklahoma City, Oklahoma. Leaders of the new company are Bert Aston and Ladora Lucas of Roswell, New Mexico, and Otto M. Vaughn of Wanette, Oklahoma.

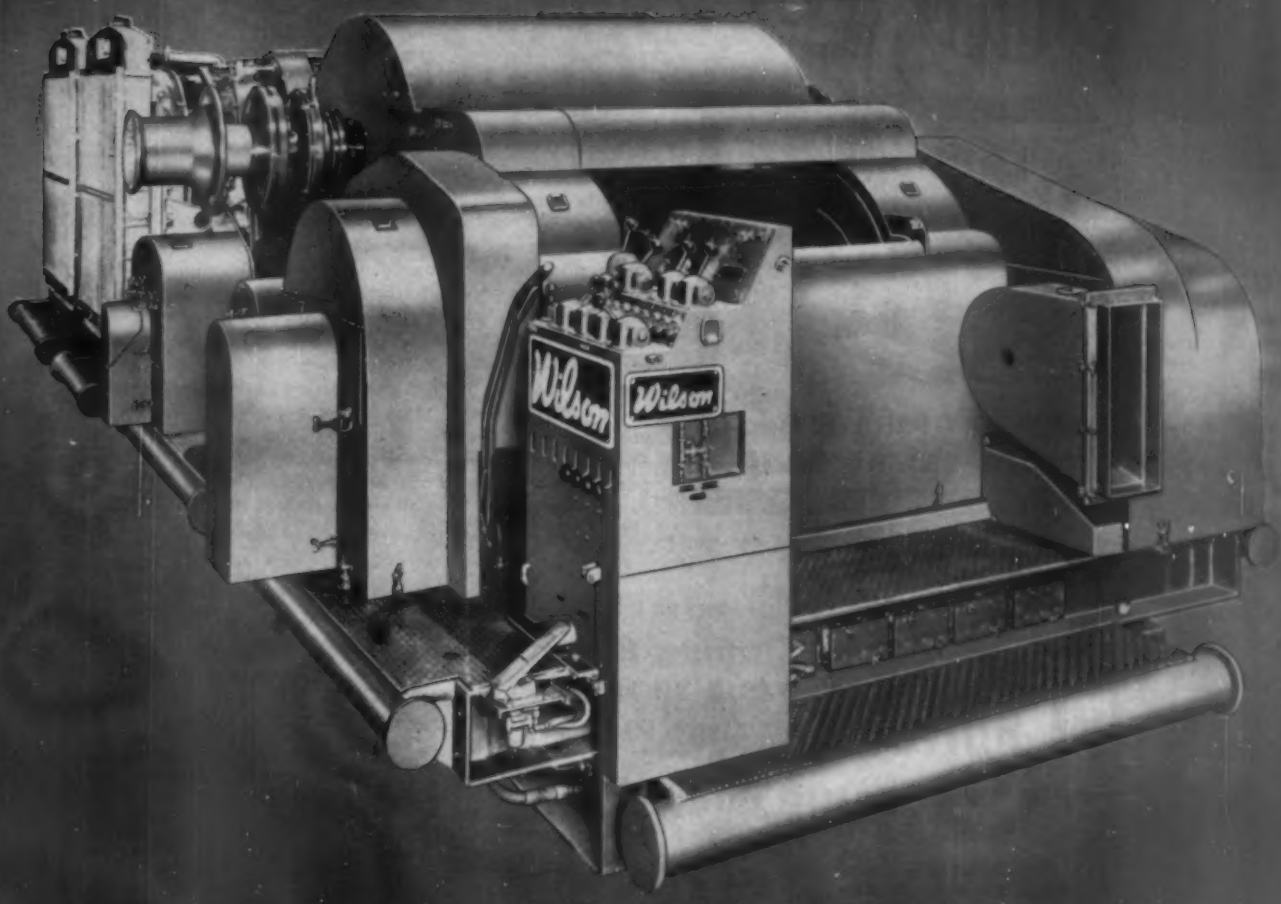
Rotary Rigs Operating in Oil Fields of United States and Canada*

	Sept. 17	Sept. 24	Oct. 1	Oct. 8
Alabama	8	6	6	8
Arkansas	21	21	16	18
Arizona	0	0	0	0
California	109	112	104	113
Colorado	64	65	68	65
Florida	2	3	3	5
Georgia	0	0	0	0
Illinois	64	75	93	81
Indiana	13	18	9	8
Iowa	1	1	1	1
Kansas	155	170	172	179
Kentucky	9	13	10	12
North Louisiana	63	62	65	68
South Louisiana	373	377	355	357
Total Louisiana	436	439	420	425
Maryland	0	0	0	0
Michigan	13	16	17	16
Missouri	1	1	1	1
Montana	47	47	46	45
Mississippi	31	29	28	28
Nebraska	27	26	27	28
Nevada	1	1	1	1

	Sept. 17	Sept. 24	Oct. 1	Oct. 8
New Mexico	136	133	128	119
New York	0	0	0	0
North Carolina	0	0	0	0
North Dakota	24	26	25	25
Ohio	1	1	1	1
Oklahoma	258	262	260	270
Oregon	0	0	0	0
Pennsylvania	8	6	9	8
South Dakota	0	0	0	0
Tennessee	0	0	0	0
Texas Gulf Coast	245	243	244	249
West Texas	368	362	372	381
North Texas	301	309	303	285
East Texas	67	66	69	70
Total Texas	981	980	988	985
Utah	19	24	25	29
Washington	0	1	1	1
West Virginia	2	2	2	2
Wyoming	82	81	85	82
United States	2513	2559	2546	2556
Western Canada	248	241	242	248
Grand Total	2761	2800	2788	2804

*As reported to the American Association of Oilwell Drilling Contractors by Hughes Tool Company.

SUPER GIANT RIG



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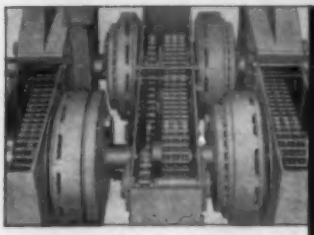

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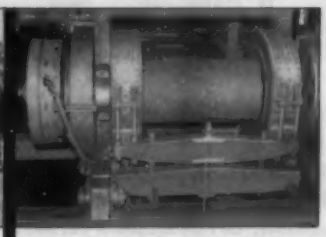

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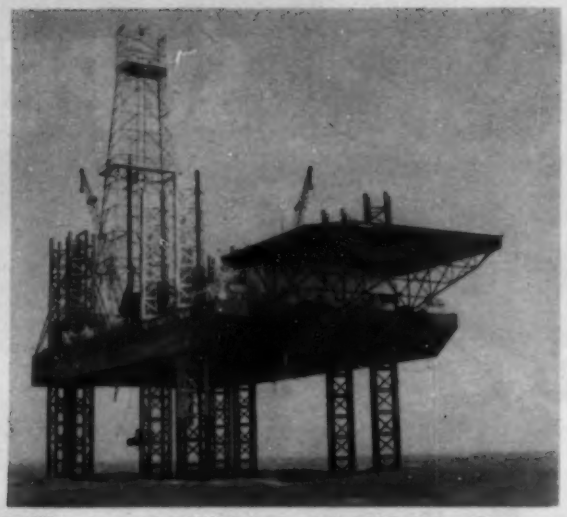
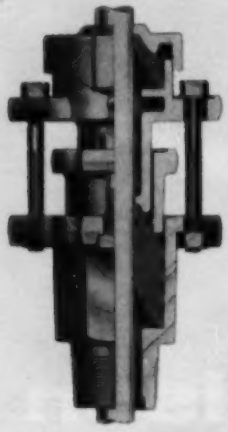


Drilling beneath 7500 ft is The Atlantic Refining Company, on Block 193 No. 1 well 22 miles offshore from the Port of Galveston, Texas. A farmout from the Tidelands Oil Corporation and the Superior Oil Company, the well is being drilled in 57 ft of water from Offshore Drilling Company's No. 55 mobile platform. This rig is capable of drilling to a depth of 16,000 ft. Spudded in mid-August, drilling operations are expected to be completed within 70 days from the start. The location, in the High Island area south of Galveston, is in sight of several successful gas and oil wells drilled previously on other blocks by Pure and Stanolind. This is Atlantic's second time at sea as operator, although the company is no stranger to offshore operations. It has 10 years' experience gained through membership in the CATC.



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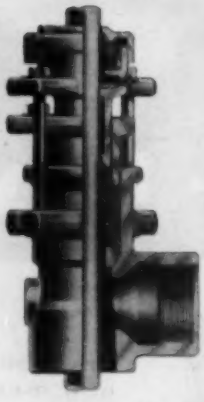

"TEE BASE TYPE" DUPLEX POLISHED ROD STUFFING BOX

A combination Stuffing Box and Pumping Tee. Makes a short connection. Bolt lugs are placed low to eliminate fouling of elevator links. No bell nipple needed as top of body will support elevator. Full opening — unnecessary to remove body when pulling or running rods.

"TYPE DP" DUPLEX POLISHED ROD STUFFING BOX

A Double Packed Stuffing Box for use on high pressure wells and those that flow intermittently. Especially desirable for wells located near buildings, fire hazards of growing crops. Two compression bolts, in bottom sections, are tightened on Cone Rings to pack-off while replacing packing in upper section.

All HERCULES Stuffing Boxes are made of high grade malleable iron which prevents shattering if rods drop. They are tested to 3,000 pounds psi pressure and all use the famous HERCULES Split Cone Packing Rings.

* All HERCULES Stuffing Boxes may be equipped with Oil Reservoir Upper Glands on "problem" wells which pump-off and burn the packing. The polished rod moves through the oil in the reservoir which lubricates and cools it.

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INSTALLATION, operation and protective features of G-E oil-well pumping starters are covered in GEA-6410. Contact your nearest G-E Apparatus Sales Office or Distributor for this bulletin, or write to the General Purpose Control Department, Bloomington, Illinois.

GENERAL ELECTRIC OFFERS . . .

2-WAY PROTECTION IN G-E OIL-WELL PUMPING STARTERS

G-E oil-well pumping starters provide electrical and mechanical protection for your equipment and personnel. Specifically designed for oil-field service, these features keep your wells flowing on schedule.

ELECTRICAL PROTECTION is assured against short circuit, lightning and undervoltage conditions. A fusible G-E HCI disconnect switch, with fuse clips that can be changed for other voltage or current ranges, helps protect against short circuits. A 3-phase arrester, solidly grounded, helps protect against lightning, and a high dropout relay guards against undervoltage conditions.

MECHANICAL PROTECTION is provided by the enclosure construction. The disconnect handle can be padlocked in the OFF position, and is interlocked with the starter door to prevent opening when power is on. The starter enclosure is sealed with a neoprene gasket to prevent the entrance of dust, rain and snow, and separate door permits checking or setting the combination timer without exposure to live parts. 733-18

Progress Is Our Most Important Product

GENERAL ELECTRIC

RUNNING TOUR with MEN in the INDUSTRY

Travis M. Kerr, formerly executive vice president of Kerr-McGee Oil Industries, Inc., has been elected vice chairman of the board of directors. **Frank C. Love,** formerly general vice president, becomes executive vice president. **A. T. F. "Tom" Seale,** formerly vice president of manufacturing, is new vice president of operations, and **G. B. Parks,** formerly manager of production and drilling operations, is new vice president of the department. Other new vice presidents are: **W. M. Murray,** of general sales; **R. M. Chesney,** of refining; and **J. W. Roach,** of crude oil supply, pipe lines, and refinery technical services.

Jack Wahl has been appointed to head the office in Calgary, Alberta, Canada, James A. Lewis Engineering, Inc., of Dallas, Texas. Also, he has been named vice president of James A. Lewis Engineering, Ltd. of Canada.

Jack Wahl

W. C. Walker

William C. Walker has been named manager of the contract department of Loffland Brothers Company of Tulsa, Oklahoma. He has been with Loffland since 1952, serving as head of the company's contract office in Midland, Texas.

John Trant, Robert Near, and **William Heine,** geologists with Ohio Oil Company, have been transferred from Sidney, Montana, to Bismarck, North Dakota.

Lewis J. Bicking, Jr., has been named production manager at the Corpus Christi, Texas, office of Pan-American Engineering Corporation, Dallas, Texas. He was formerly division engineer for Ashland Oil & Refining Company.

Jerald M. Goldberg has been added to the staff of William J. Carey at the headquarters offices in Dallas, Texas. Goldberg was most recently staff geologist for D. D. Feldman Oil and Gas in Dallas. He will be district geologist in charge of West, West Central, and North Texas.

William T. Smith has been named division geologist in Stanolind Oil & Gas Company's North Texas-New Mexico division. **Lawson F. Jacks, Jr.,** replaced Smith, who was formerly district geologist and supervisor for exploration in the Abilene, Texas, district.

Robert J. Beams has resigned as chief petroleum geologist and engineer for Howell, Holloway & Howell to enter independent oil business with headquarters in Dallas, Texas.

Ralph E. Damp has been elected president and director of the Swan-Finch Oil Corporation. He was formerly with Carter Oil in Oklahoma.

George R. Kinter has been named assistant manager of Tidewater Oil Company's gas utilization department. **Arthur M. Mouser** has been made divisional petroleum engineer. He replaces **J. E. Bailey,** who will become assistant to the production manager. **J. M. Tharp, Jr.,** who was district superintendent offshore operations, was transferred to the company's western division. Replacing Tharp is **George H. Truran.**

Leo Dean, Midland, Texas, has been transferred to Morgan City, Louisiana, as drilling superintendent, Gulf Coast district, Llano Drilling Company. He will be in charge of offshore operations. **Otis Goode** of Odessa, Texas, has been promoted to drilling superintendent, West Texas-New Mexico district, the position formerly held by Dean, and will be in charge of the firm's rigs in the Permian Basin.

Edgar L. Cralle has been appointed district superintendent, and **Keith Van Horn** as district engineer at Odessa, Texas, for Cities Service Oil Company's production division. Cralle assumes the post of district superintendent vacated recently when **Don L. Kastner** was appointed assistant division superintendent for West Texas and New Mexico.

Everett L. Vilander has been appointed public relations representative for the Shell Oil Company exploration and production area covering several mid — and southwestern states, headquartered in Tulsa, Oklahoma. He was formerly public relations representative, New Orleans, Louisiana, for Shell.

Neal Colby, contact representative for Garvey Drilling Company, has been transferred from the Great Bend, Kansas, office to the firm's new office in the Cravens Building, Oklahoma City, Oklahoma.

Ballie W. Vinson, formerly president of The Exploration Drilling Company, has been named chairman of the board. **B. E. Groenewold,** formerly vice president and general manager, now is president of Exploration.

George O. Relf of Houston, Texas, has been named exploration manager for the Houston production division of Gulf Oil Corporation. His former position has been division chief geologist for the Houston production division.

Husky Oil Company has announced the promotions of **James R. Learned** to manager, land and exploration, and **M. F. Westfall** to manager of operations.

Learned was general attorney for the company serving since 1949.

Westfall came to Husky from Cities Service Oil Company in 1952, as assistant production superintendent, most recently serving as production superintendent.

F. C. McLarty has joined Plymouth Oil Company in its Sinton, Texas, headquarters office as assistant chief civil engineer. He was formerly civil engineer with The Goldston Company.

James E. Buckley, with Sun for 43 years, has been appointed division land manager of Sun Oil Company's southwest division. Buckley will succeed **George W. Chapman. John W. Storey** will become regional landman. He will assume the duties handled by Buckley. **Pressley E. (Red) Langley** will assume the duties of Storey as district landman, Abilene, Texas.

William H. Neely, formerly geologist with Morris G. Spencer in Dallas, Texas, is now geologist for the Harry Bass Drilling Company, Dallas.

Cecil V. Hagen has been elected president of the board of directors of Gulf Coast Leaseholds, Inc. He succeeds **Robert G. Behrman, Jr.,** who has resigned to enter the oil business with his own company. Also announced is the resignation of **William P. Swearingen,** vice president in charge of drilling and production. **R. L. Oliver,** controller of the company, has been elected vice president.

Zack Pruett, president of the Gonzales National Bank, **A. C. Mackay,** comptroller of Venezuela Syndicate, Inc., and **Fisher Jones,** general manager of Corpus Christi Development Corporation, have been elected to the board of directors.

John Hill, district geophysicist, Wichita, Kansas, for the Carter Oil Company, has transferred to Oklahoma City, Oklahoma, as assistant division geophysicist. **Ralph Brewer,** formerly with Central Exploration, succeeds Hill.

Petroleum Exploration, Inc., is a new consulting and development firm at Amarillo, Texas, formed by **T. B. Pickens, Jr.,** geological consultant; **Robert E. Aikman,** former district landman for Cities Service Oil Company, and **Richard L. Parker,** former geologist with Union Oil of California.

Howard L. Garrett, Shell Oil Company, has been elected president of the Billings, Montana, Geological Society.

Simon Lebow, independent operator of Tulsa, Oklahoma, has opened a district office at Owensboro, Kentucky. **Bert I. Lebow** has been named manager.

Dr. E. M. McNatt, assistant manager of the geophysical division of the exploration department of The Carter Oil Company, Tulsa, Oklahoma, has been appointed geophysical adviser in the exploration division of the producing coordination department in the New York City offices of Standard Oil Company (New Jersey). **Marvin Romberg,** division geophysicist in Carter's western division office at Denver, has been named to replace Dr. McNatt in Tulsa as assistant manager of geophysics for the company.

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Service
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New Services • • • New Tools • • • New Methods • • • Outstanding Results

McCullough Log Saves $40.00 Per Foot Coring Cost in Offset Well

This was well #2 of a drilling program, an offset to the first well in the area which was cored completely. Depth of operation was below 5,000 feet. 5½" O.D. 15 lb. casing had been cemented through the pay zone.

A McCullough Radiation Well Log was run obtaining Gamma Ray and Neutron curves and a simultaneous collar log. McCullough's Logging Engineer computed porosities from the Neutron Log, applied shale and thin bed corrections and located the 18 foot oil zone to be perforated between 5,050 and 5,068 feet. The porosity graphs and slope of the curves were determined from cores from the key well.

108 improved ½" Ogival Bullets were fired in the pay zone, six per foot, by 4¾" O.D. McCullough M-3 Bullet Perforators. Result: A good well, and it took only four hours to complete the logging and perforating.

Other offset wells in the field will be completed in the same way, saving $40.00 per foot in coring costs through the zones that would ordinarily be cored.

This is another fine example of the accuracy and reliability of the McCullough Radiation Well Logger, and its outstanding value as a correlative instrument.

McCullough Log Helps Turn Water Well Into Oil Well

McCullough Radiation Well Logger Accurately Locates 3½ Foot Oil Zone Missed by Previous Log.

While this was a wildcat well, the producing horizon had the same general characteristics as other wells in the basin; the usual gas cap, a very thin oil zone and a transitional zone. It was a typical tough completion problem calling for exact, detailed logging information and "pin point" accuracy in perforating.

First logged and perforated by another service company, the well flowed water. Depth of operation was below 5,500 feet and 5½" O.D. 14.5 lb. casing had been set through the producing horizon.

After squeezing to shut off the water flow, the operator called McCullough. A McCullough Radiation Well Log was run obtaining Gamma Ray and Neutron curves and recording a simultaneous collar log.

The McCullough Radiation Well Logger is the most accurate, reliable and efficient logging instrument available. It has greater stability, provides more detail and assures more accurate quantitative interpretation. You can be sure of exactly locating, defining and interpreting potentially productive formations—thick or thin.

It was found that the previous log had been ten feet deep on casing collars, formation tops and total depth measurements. In addition the log had been interpreted so that the oil zone was shown to be 30 feet into the transitional zone.

The McCullough Log accurately identified and exactly located the gas cap, a 3½ foot oil zone, then the transitional zone. The gas cap contact was perforated for a squeeze shut-off and the 3½ foot oil zone was perforated by ten McCullough Super Formation Glass Jets. The well was then fractured and is now a good, commercial, water free oil well. Total logging and perforating time was only three hours.

There are many actual jobs such as this where the accurate, reliable, easily interpreted information provided by the McCullough Radiation Well Logger has turned a total loss into a profitable operation.

For best results, always call for the McCullough Radiation Well Logger. The most dependable logging equipment available.

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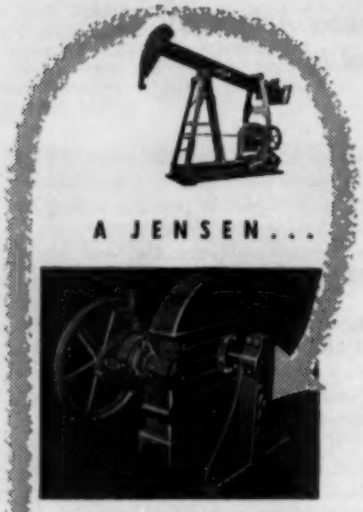
Running Tour

▸ **Dr. S. K. Chakravorty** has been appointed production manager of New Superior Oils of Canada, Ltd., succeeding **B. H. Corey,** who resigned. Dr. Chakravorty has served as chief petroleum engineer for New Superior Oils since 1953. He received his master's degree from the University of Calcutta, completed his undergraduate work at the Colorado School of Mines and obtained his PhD from the University of Kansas. He formerly was Chief Oil and Gas Conservation Officer with the Saskatchewan Government.

Dr. Chakravorty



On-the-spot production records prove that a JENSEN JACK can make your well more profitable. Get the proof first hand. No matter what type equipment you are now using, no matter where your well is located, check your present production records with records established by a JENSEN JACK under the same conditions. See for yourself how much more profitable a JENSEN is — with less servicing and less down time. Write us now... or see your JENSEN Dealer.

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▸ **R. H. Coe** of Midland, Texas, has been transferred to Tulsa, Oklahoma, as division engineer of production department for Tidewtaer Oil Company. He was formerly district production engineer in Midland.

▸ **Joseph W. Graybeal** of Midland, Texas, has been named western division petroleum engineer for Humble Oil & Refining Company. He succeeds **Robert S. Dewey,** who retires from that position after more than 30 years of service.

Ray A. Baze, who has been a reservoir engineer in the division offices, has been promoted to assistant division engineer, the position formerly held by Graybeal.

▸ **Earl Clifford** has been appointed office manager and chief accountant of the Reed Drilling Company, Tulsa, Oklahoma. He formerly was with Sunray Mid-Continent Oil Company and Bethlehem Steel Corporation.

▸ **F. H. Taylor,** has been named special assistant to the production manager of Shell Oil Company, Midland, Texas. He was promoted from division production manager at Casper, Wyoming.

▸ **Malcolm A. Knock** has been promoted to district geophysicist of Stanolind Oil and Gas Company's Lake Charles, Louisiana, district office. He replaces **F. W. Popp,** who was transferred to Venezuela to do geophysical work for the company.

▸ **John W. Green,** manager of The Texas Company's Houston, Texas, sales division, has been promoted to manager of the firm's 11-state Southern region. Succeeding Green is **D. B. Munroe,** former assistant division manager.

▸ **Frank C. Osment** has been named as manager of exploration planning of Stanolind Oil & Gas Company. He was formerly assistant chief geologist in charge of programs.

▸ **Lonnie W. Wege,** attorney of Mound City, Missouri, has been appointed assistant manager of the industrial relations department of Cities Service Gas Company, Oklahoma City, Oklahoma. He succeeds **Robert E. Hill,** who transferred to Petroleum Chemicals, Inc., New Orleans, Louisiana.

▸ **W. W. Jones,** formerly with Don Slape Drilling, has formed the Woody Jones Drilling Company, with offices at Olney, Illinois.

▸ **Richard J. Harwood,** formerly vice president of OPER, Inc., has been named division exploration manager for Rocket Drilling Company, Inc., Wichita, Kansas. **Bill Peterson** has been named division geologist for the company, succeeding **James Thompson,** who resigned to become a consultant.

▸ Alex W. McCoy Associates, Inc., Tulsa, Oklahoma, has employed **Wayne E. Swearingen** as chief engineer to head the newly established engineering department.

A graduate of the University of Oklahoma, he was formerly with Stanolind Oil and Gas Company and Herman Kaveler, Tulsa, and has been active in consultant work as an appraiser of oil and gas properties for primary and secondary recovery.

▸ Five appointments for the 1957 national convention of the Society of Exploration Geophysicists have been announced.

They are: **E. O. Vetter** will be assistant general chairman and chairman of the finance committee. Vetter is administrative vice president of Geophysical Service, Inc., Dallas, Texas; **Glen M. Conklin** will be chairman of the technical program committee. Conklin is seismograph section head, southwestern division, Sun Oil Company, Dallas; **John Cathey,** chief geophysicist for Seaboard Oil Company, Dallas, will be chairman of the exhibits committee; **M. C. Kelsey** will be the chairman of the entertainment committee. Kelsey is president of the Rayflex Exploration Company, Dallas. The housing committee will be headed by **O. C. Clifford, Jr.,** who is chief geophysicist of The Atlantic Refining Company, Dallas.

▸ **Thomas A. Parks,** senior geologist for Sohio Petroleum Company, and **Victor M. Naimish,** senior landman, have both been transferred from Regina, Saskatchewan, to Calgary, Alberta, Canada. **John S. Ambler** has been promoted to senior geologist to replate Parks at Regina, and **A. Ross Long** will replace Naimish as landman there.

▸ **J. J. (Jerry) Wright,** senior development geologist for The California Company, New Orleans, Louisiana, has resigned to join Coronet Oil Company. He will open a Gulf Coast exploration offices for Coronet in Lafayette, Louisiana.

▸ **Vernon J. Hunsicker,** seismologist with Petty Geophysical Engineering Company in San Antonio, Texas, has joined Texas Gulf Producing Company in Houston, Texas, as geophysicist.

▸ **L. C. Ritts,** division geologist for Stanolind Oil & Gas Company, Houston, Texas, has been promoted to division exploration superintendent. He succeeds **W. C. Imbt,** who has been transferred to Albuquerque, New Mexico. **T. D. Barber,** Houston district exploration superintendent, will succeed Ritts as division geologist.

Seagoing OIL RIG

For complete information, write:
The INGALLS Shipbuilding Corporation
Birmingham, Alabama

The higher strength of this latest and greatest development in wire rope construction... Yellow Strand "POWERSTEEL"... is the answer to today's longer and heavier strings of drill pipe.

Yellow Strand "POWERSTEEL" is a premium wire rope. For a small additional initial investment you get much more in ton-mile service.

Your Continental man can quickly explain how "POWERSTEEL" can save you money. He can also show how even more can be saved through using the Yellow Strand Tailored Cut-off Plan.

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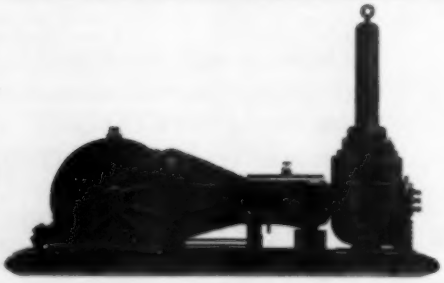

Gardner-Denver Mud Pump Service Specialists are available in any and all drilling areas.

It's an accepted fact that all mud pumps require service for best performance.

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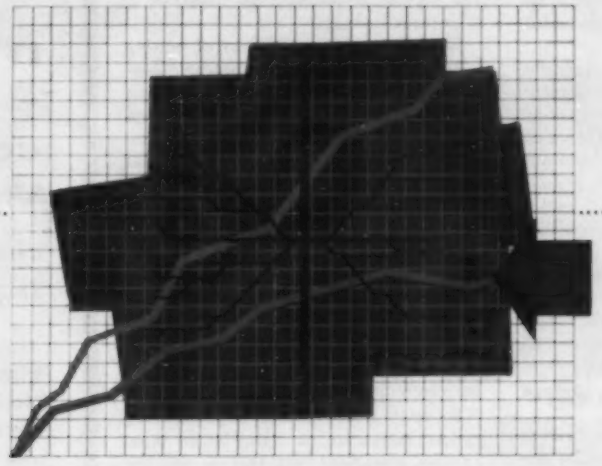
CUTS COSTS OF BIG VOLUME FRACTURING



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Big volume fracturing may sound expensive, but it needn't be...if you specify Halliburton's SANDOIL fracturing. SANDOIL gives you big volume with big economy. That comes from Halliburton's unmatched combination of research to develop better low-cost fracturing fluids and more efficient equipment... capable of continuously pumping huge volumes at high pressures... plus the know-how that comes from 7 full years of experience in fracturing oil and gas wells for big production increases.

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CONTINUOUS PROPORTIONING GIVES RIGID CONTROL

Further effectiveness is gained by Halliburton's continuous blending and proportioning equipment. This provides for: 1. Changing sand concentrations over wide ranges at any time during the fracture treatment; 2. Controlling and measuring the sand concentration going into the well at all times; 3. Mixing large quantities; 4. Operating at high rates of injection.

Add them all up and you will have just a few of the reasons why SANDOIL has obtained increasingly profitable production... at lower over-all cost. Call your local or district office of the Halliburton Oil Well Cementing Company, Duncan, Oklahoma.

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HALLIBURTON FRACTURING SERVICES

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Ad Editorial

VALVE TIGHTNESS and what it means to economy-minded management

Valves are one of the most vital components of oil and gas production – no modern operation can be conducted without them.

Valves are costly, yet they generally receive less attention from management than most purchased items. Few users or buyers actually know what is in a valve or how it functions. Many less important items are purchased with much greater deliberation and maintained with greater care, yet few items are more important than valves.

Their most important function is to shut off flow – completely – TIGHT. Yet few valves are actually tight. Most valves do leak – and leakage is expensive – a continuing hidden cost. Frequently, leakage is dangerous. Leakage is never a good thing.

Tightness is the element in valves which tells the story – the one thing for which valves should be specified and purchased – tightness is worth recognizing and worth getting.

Economy is another important element in valves – the initial cost and the maintenance cost must be considered seriously. Far too many valves are purchased for reasons not at all important to those who "pay the bills."

Habit, friendship, shape, size, weight, "easy to turn," "can't be bothered with maintenance," and similar thoughts frequently decide the make and type of valves specified and purchased.

It is time for economy-minded management at all levels to give thought to the many valves now in use, and the many to be purchased and installed in the months and years to come, because valves once installed must be lived with a long, long time, and continuing leakage and excess maintenance costs can take a serious toll from profits.

Although valves may look alike on the outside, they are not alike on the inside, and it is the inside which is most important. Clean, functional simplicity is a fundamental necessity to maintain good working order under the severe conditions in which valves must perform.

Think, for a moment, of the loads imposed. A 2" full opening valve (2 1/16" bore) under only 1000 psi has a gate-to-seat load of 3,404 lbs. This is 1.7 tons. Yet these two parts are moved back and forth against each other in fluids and gases containing contaminants at high velocity and under far from ideal conditions. Under 3000 psi (not uncommon in Christmas tree and flow lines in the fields) a 2" valve carries a load of over 5 tons in *sliding frictional contact* between the sealing surfaces of the gate and the seat!

No wonder that most valves do leak! The higher the pressure the harder it is to prevent leakage.

No one would ever dream of putting a piping system together without "doping" the threads and "gasketing" the flanges. The API Standards set forth steel rings, flange dimensions and specified bolting for various ratings in order to provide safe *tight* joints. These joints are carefully cleaned, and made up tightly. The ring joint gaskets and flange grooves never move in relation to each other, and with reasonable care on assembly they never leak. Yet the same pressure they hold (clean and without movement) is imposed upon valve gates which suffer movement upon seats and are rarely in clean fluid.

It may seem almost impossible to expect valves to be tight under these adverse conditions but this is not the case. McEvoy Valves are tight because they are "gasketed" between the gate and the seat.

A simple system of reservoir, passageway, and seat groove is so arranged that *sealing* compound (*not* grease) is automatically injected between the faces of seat and gate after *each* closing of the valve. This compound forms a leak-proof *gasket* at these mating surfaces so that leakage cannot exist, regardless of conditions of pressure, load of gate on seat, dirt and contaminants, etc.

This is the heart of the McEvoy valve. A system proven by the thousands of McEvoy installations in round-the-world service at all pressures and conditions found in the fields. Hence, tightness – economy is yours at no extra cost.

Maintenance-economy is just as important to the user. This is provided by the reservoir of sealing compound. An extremely small amount of this impervious compound is used each time the valve is operated, and the reservoir contains an uncontaminated supply which lasts from 50 to 150 operations of the valve without renewing (or filling) the reservoirs. Generally these valves require no more than one or two servicings a year. Isn't this a small expense compared to the length of leak-free service rendered?

May we consult with you concerning your valves? We honestly believe we can save you money and provide safer, better operating conditions for you. Let's talk *Tightness* with the attendant economic benefits you can enjoy when you use McEvoy Valves.

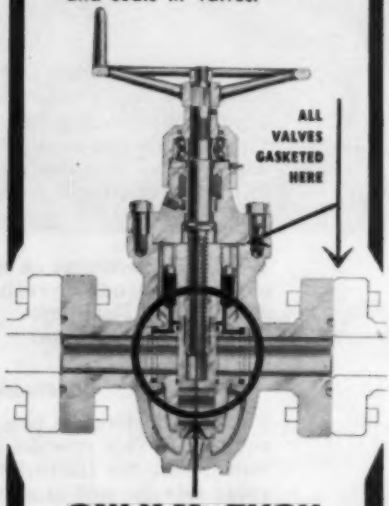
Call, write or wire McEvoy Company, Texas and Milby St., P. O. Box 3127, Houston 1, Texas.

IT'S A FACT:

ALL TIGHT CONNECTIONS ARE GASKETED!

and tightness is important to you

It is common practice to place *gaskets* between flanges, and *"dope"* on threaded connections to provide *tightness* at such joints. There is no movement between these parts, but there *is* movement between gates and seats in valves.



ONLY McEVOY VALVES ARE GASKETED HERE

. . . and **gasketing** at this point is essential to maintain **tightness.**

McEvoy COMPANY

OIL WELL EQUIPMENT

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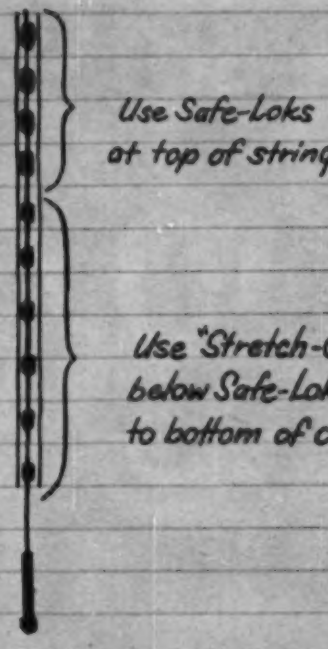
Houston 1, Texas

Here's how to combine Safe-Lok and Stretch-On Protectors for maximum protection at lowest overall cost!



SAFE·LOK

STRETCH·ON

PB PROTECTORS

Two different types of PB drill pipe and casing protectors are in use today. One is the popular PB "Stretch-On" which has been the favorite of the oil patch for years. The other is the relatively new PB Safe-Lok Protector which drilling crews can install or remove in seconds. These two protectors are natural partners in casing protection. Here's how this combination benefits you:

Safe-Loks are *time and money savers* at the top of your drilling string. Here their instantly removable and replaceable feature eliminates the laying down and picking up of rubbered pipe. You simply *remove* Safe-Loks (based on estimated bit footage) as pipe comes out of the hole, providing unrubbered pipe in the derrick for make-up behind your new bit.

You eliminate three time-wasting operations: (1) unnecessary transfer of rubbered pipe from derrick to pipe rack; (2) the handling of unrubbered singles from the rack for bit make-up; and (3) the return of rubbered pipe from the pipe rack for use within casing. Pipe is handled in *stand lengths in the derrick*. Safe-Loks are quickly replaced on unrubbered stands at the top of the string as you go back in the hole.

PB "Stretch-On" Protectors are used to provide protection on all pipe where protector removal and re-installation is not a factor.

Use this new money-saving PB protector combination on your longer strings. And use PB Safe-Loks exclusively on all shallow drilling.

Write for complete PB catalog...

including special clearance charts for selection of correct protector size.

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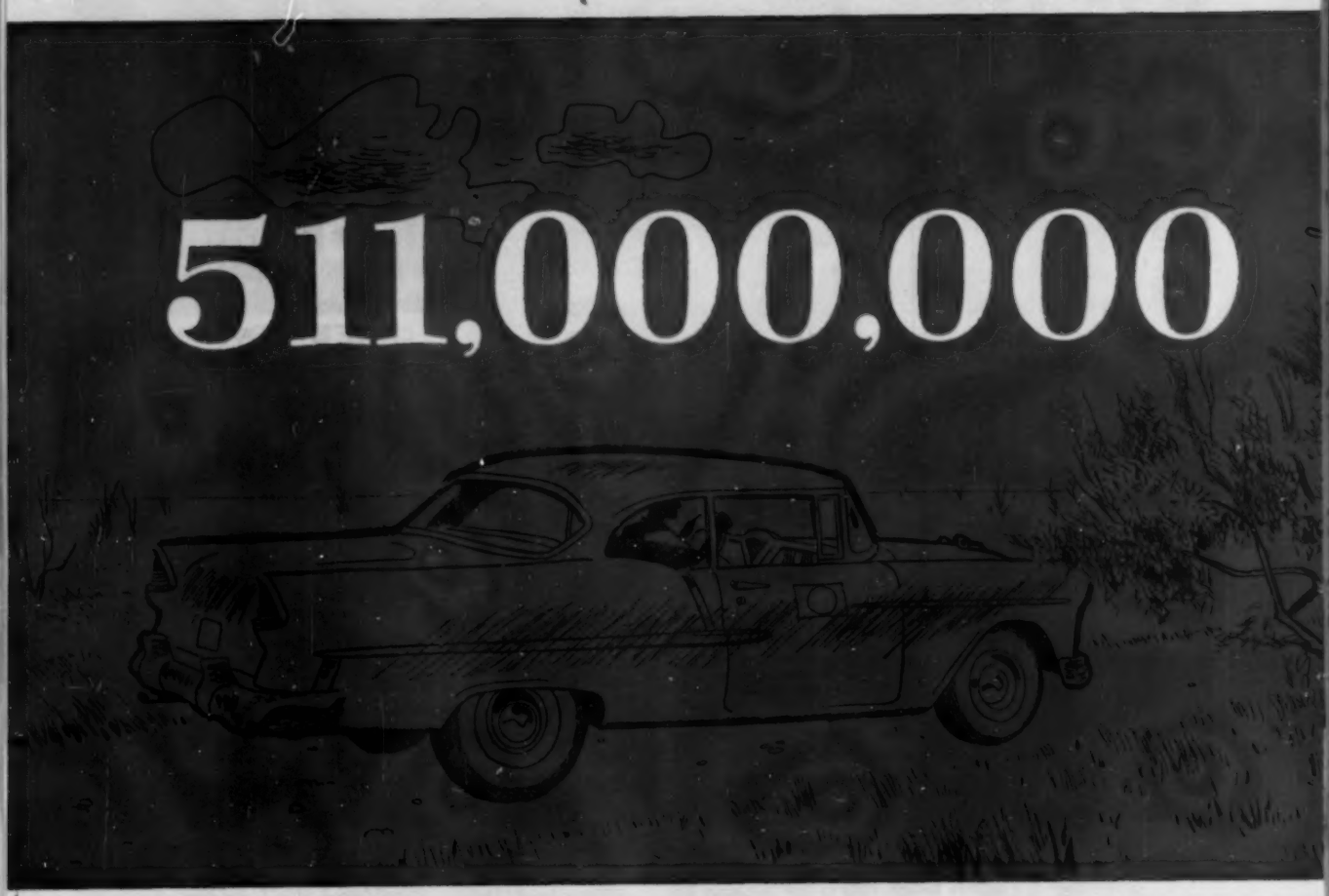


Thanks to the spur of keen competition among our members—and their innate desire to back up their continually improved products and special services with helpful technical assistance

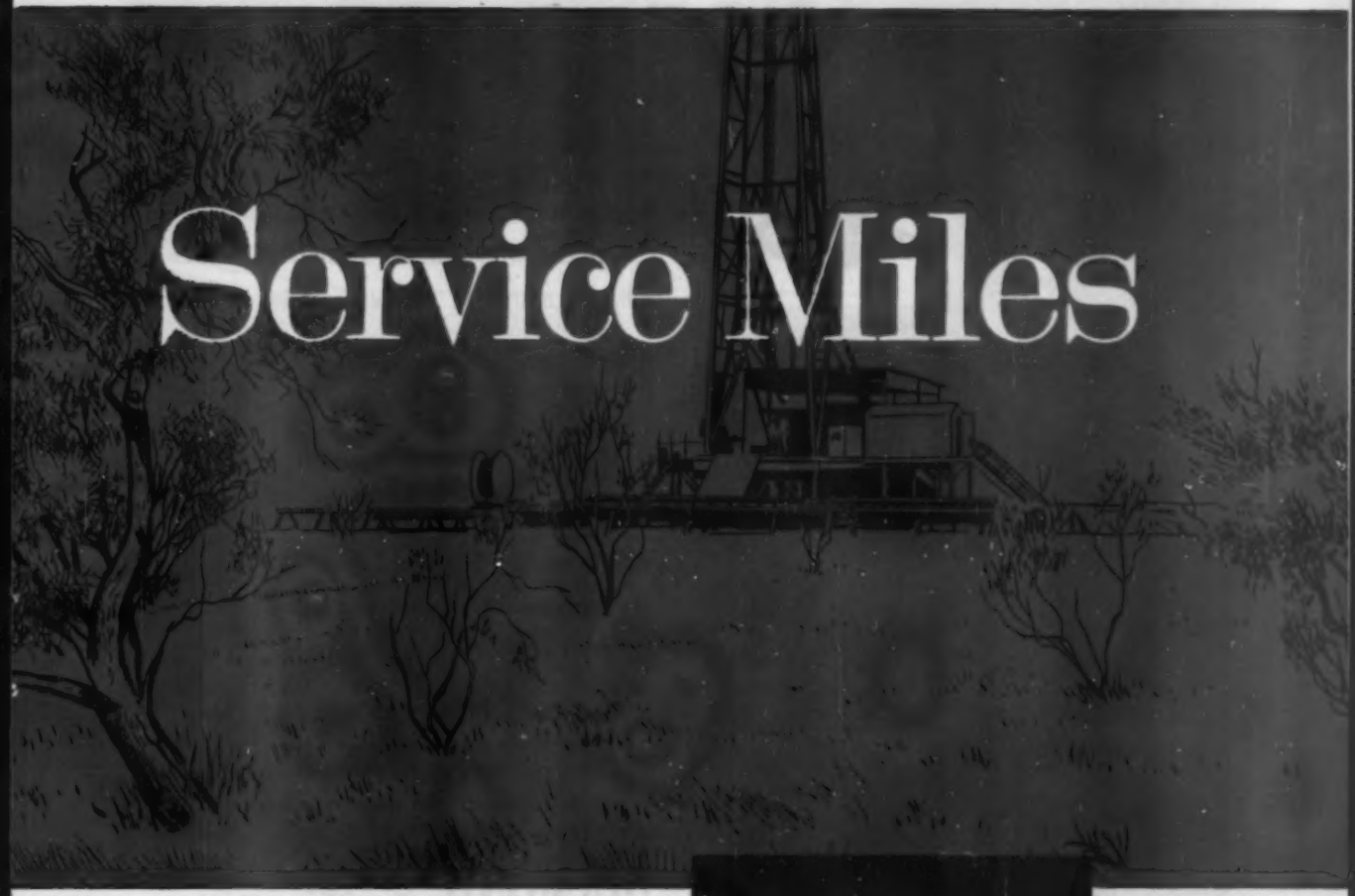
. . . we* give our customers outstanding service—as proved by the fact that our service cars, trucks, and pickups travel *511,000,000 service miles a year;*

. . . we* back up our products and special services with *9,000 engineers,* composed of research scientists, development engineers, metallurgists, production engineers, and field service engineers;

. . . we* back up our products and services with *plants and equipment worth billions of dollars* in order to supply our customers with constantly improved equipment and services in *quantities wanted . . . when wanted . . . where wanted.*

***Manufacturers . . . Supply Companies . . . Service Companies**

rdinary service

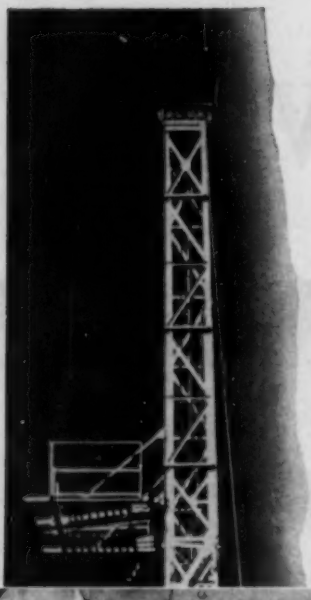


Service Miles

P.E.S.A.*

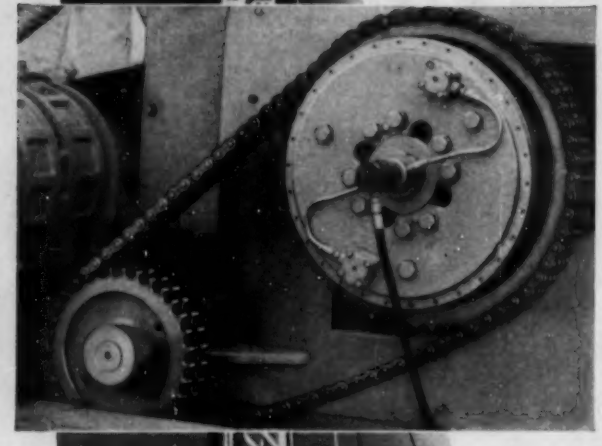
Composed of: manufacturers whose plants make the finest precision equipment . . . supply stores who add two other ingredients of value — where you want it — when you want it . . . service companies who make available to their customers the practical results of the theoretical research of some of the most brilliant scientific and technical men in the world.

*PETROLEUM EQUIPMENT SUPPLIERS ASSOCIATION



NEW FAILING STRATMASTER EQUIPPED WITH DEPENDABLE DIAMOND ROLLER CHAINS

DIAMOND



New efficiency, light weight and simplicity of operation cut costs and speed drilling on the new George E. Failing Stratmaster.

On the drawworks, Diamond Roller Chains maintain highest efficiency and provide maximum operating life with minimum service.

The continued preference for Diamond Roller Chain by leading rig manufacturers and drilling contractors is evidence that superior Diamond quality provides the dependability and efficiency to keep drilling costs down.

DIAMOND CHAIN COMPANY, Inc.

Where High Quality is Traditional

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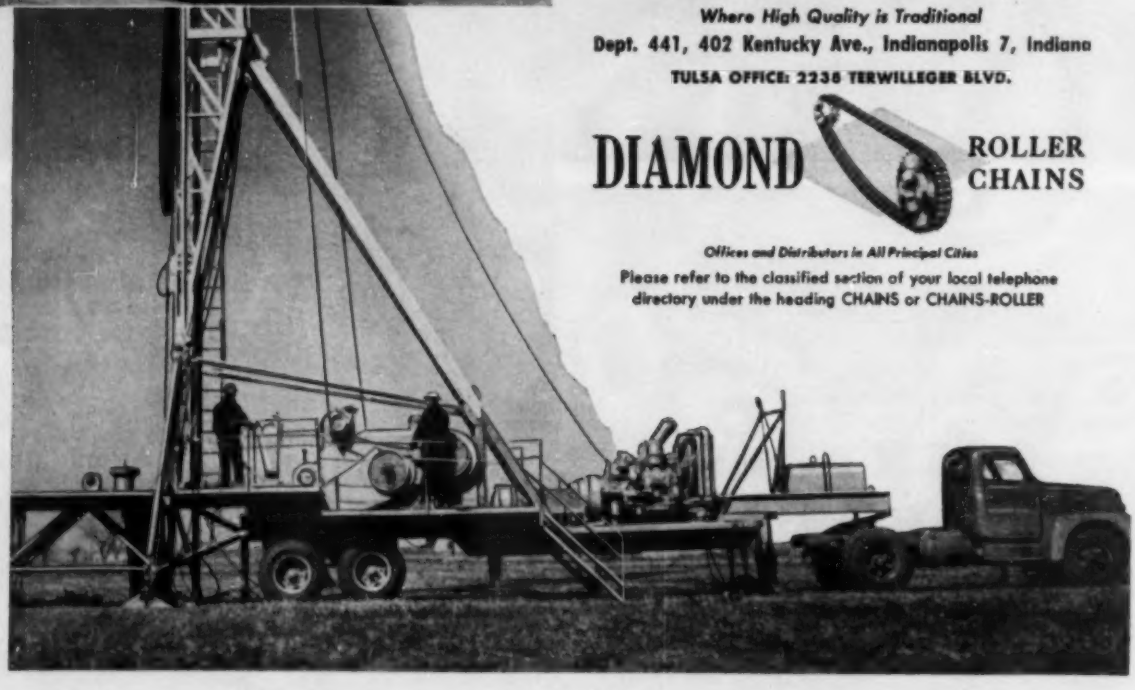
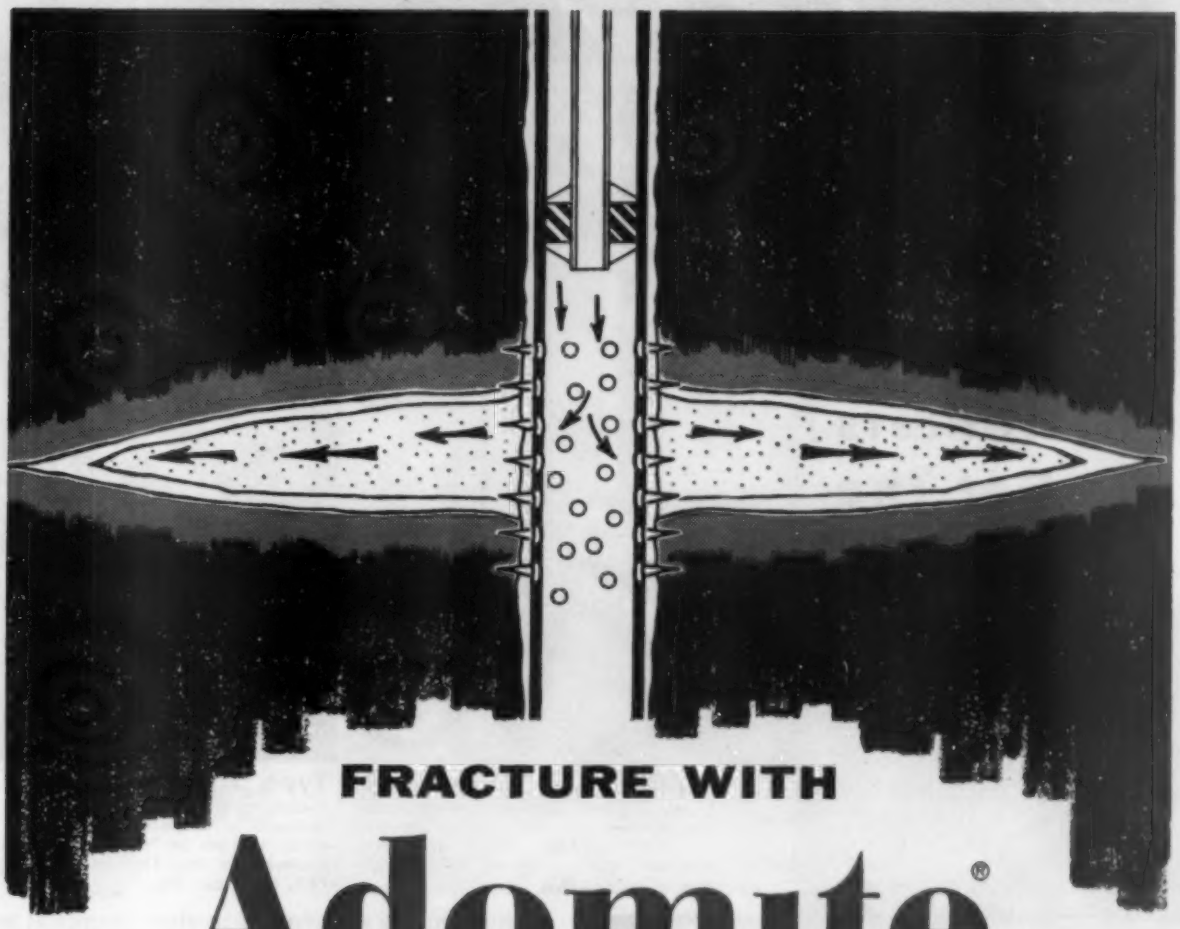
DIAMOND **ROLLER CHAINS**

Offices and Distributors in All Principal Cities

Please refer to the classified section of your local telephone directory under the heading CHAINS or CHAINS-ROLLER



CUT FLUID LOSS TO A MINIMUM



FRACTURE WITH

Adomite®

Specify the fluid-loss control agent proven profitable in thousands of successful field treatments

Only Adomite gives you all these advantages— so effectively	Larger fracturing per volume of treatment—or the same size fracture with a lesser volume of fracturing oil.	Acceptance of fracturing fluid by pipeline companies —fracturing oils made from lease crude and Adomite are completely acceptable to pipelines.	Fewer sand-outs. Adomite prevents loss of fluid into the rock matrix, preventing buildup of sand concentration in the fracture.
Lower transportation costs. The fracturing oil costs you nothing when you use your own lease crudes.	Decreased friction losses. The low viscosity of Adomite-treated crudes or gelled crudes permits the use of less pumping equipment than viscous refinery residuals.	Compatibility of fracturing fluid with reservoir oils. Since Adomite is used with lease crudes, the fracturing fluid is fully compatible.	Fluid loss control with one additive. Adomite is all you need to control fluid loss of kerosene, crudes, gelled crudes or refinery residuals.

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BE SURE TO TELL YOUR SERVICE COMPANY TO USE ADOMITE

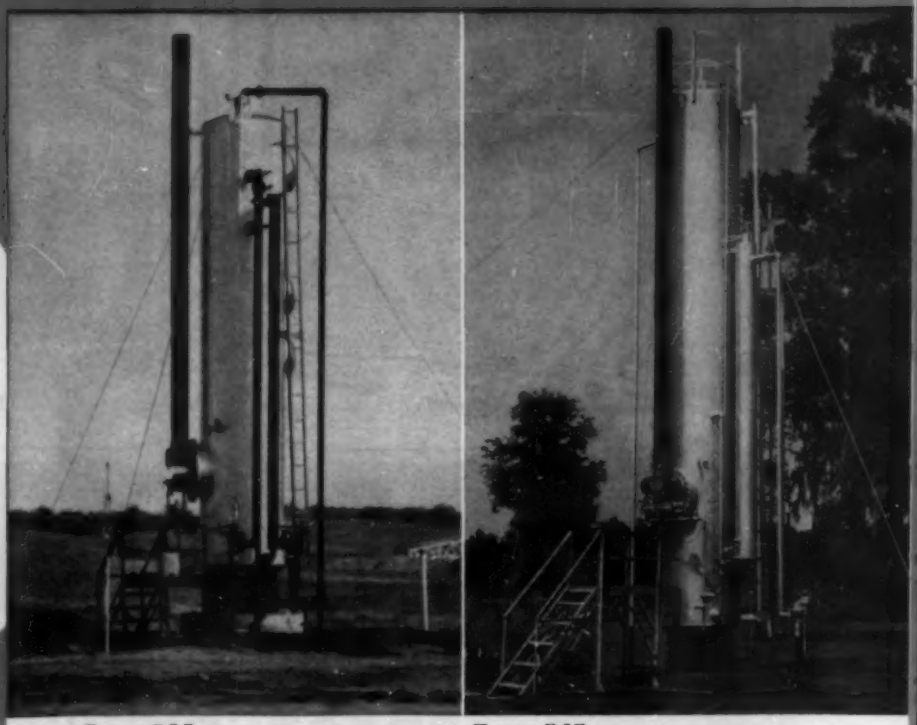
Adomite—developed and manufactured by Continental Oil Company

Adomite®—trade-mark, Continental Oil Company

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

For *Average* or *Tough* Treating Jobs...

BS&B
Treaters Get The Job Done ...Right!



Type "S" The BS&B Type "S" Vertical Treater is a well balanced unit with excellent performance characteristics for low cost treating under average conditions. Available in sizes to treat 100 to 2500 bbls. of oil per day.

Type "J" The BS&B Type "J" Vertical Treater is a high performance level unit designed to handle large volumes of oil, water and gas on "tough" treating jobs. Available in sizes to treat 100 to 3600 bbls. of oil per day.

Model "HGT" Where a Horizontal Treater is indicated because of large volume requirements, broader distribution of weight on marshy ground, wind loading and anchoring conditions, etc. we strongly recommend the BS&B Model "HGT"." This treater will handle even the "toughest" treating jobs under the most adverse conditions. Available in sizes to treat 100 to 16,000 bbls. of oil per day.

Some makes and types of treaters operate at much higher efficiency than others under a given set of operating conditions. Some require a lot of expensive "down time" for maintenance and repairs. But lease operators of *experience* know that when they buy a BS&B Treater, they need have no concern on either count.

No matter how "average" or how "tough" the operating conditions on *your* lease, there's a right size and type of BS&B Treater for the job *you* have to do! BS&B Treaters are famous throughout the industry for their optimum operating results at lowest operating cost.

Don't be "shortchanged" by operating any treater on your lease that fails to deliver *maximum return per dollar invested!* Your BS&B Man will be glad to assist you in selecting the best treater for *your* conditions.

BLACK, SIVALLS & BRYSON, INC.

Oil & Gas Equipment Division, Dept. I-CII
P.O. Box 1714 Oklahoma City, Oklahoma

EFFICIENCY OVER 60 YEARS BS&B RELIABILITY
ANOTHER EXAMPLE OF PRODUCT LEADERSHIP

Buy a BS&B Treater... and get the job done... RIGHT!

ALTEN
PUMPING UNITS

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PUMPING their way to Leadership

Thousands of Alten units—operating for years with low, low cost records—are pumping their way to leadership. Put them to work for you!

A full line of 47 models and types including small beam balanced units, beam and crank balanced models, or medium and larger types with the Alten screw-type adjustable counter balance. You can be sure of peak performance with every model in each series.

Ask at your local supply store or write Alten for latest catalogue and engineering information.

Worldwide Distribution Through Supply Stores

-ALTEN-
Foundry & Machine Works, Inc.
LANCASTER, OHIO

Still on the job after 9 years with

MARVEL INVERSE OILER—

Vital Part of World's Finest Engines

The Marvel Inverse Oiler ⟶

is an integral part of the Waukesha NKRU gas unit. Operating off the intake manifold, this completely automatic Oiler feeds Marvel Mystery Oil exactly in proportion to engine loads . . . gives direct protection to the all-important upper cylinder areas.

STILL ON THE JOB after *nine years'* service! This dependable Waukesha NK Series engine, pictured above, has *never* had the head or pan off in all this time.

Like most fine performers, the Waukesha engine is equipped with a Marvel Inverse Oiler for Marvel Mystery Oil—finest performing lubricant on the market.

For engine manufacturers have found that engines equipped with Marvel Inverse Oilers, can be depended upon to give quick acceleration to save trip time . . . keep operating costs to a minimum . . . guarantee hours of continuous performance . . . keep "down time" low by extending periods between overhauls.

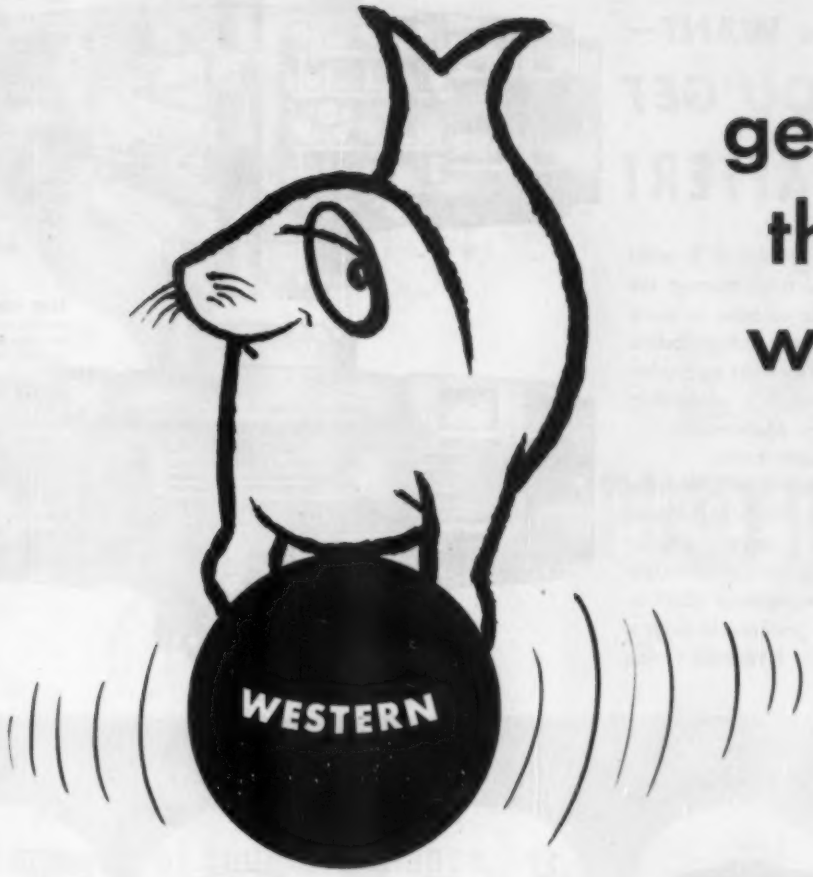
The Marvel Inverse Oiler, incorporated as a vital unit in the engine's lubrication system, feeds Marvel Mystery Oil in exact proportion to engine speed and load . . . properly lubricating valves and guides, preventing wear and sticking. It keeps upper piston rings free in their grooves . . . retards ring flutter . . . and cushions ring pounding which can result in ring breakages.

Of course, it is actually the oil that performs these functions and only Marvel Mystery Oil is blended for this purpose and for the Marvel Inverse Oiler!

See Your Local Jobber or Oil Well Supply House

EMEROL MFG. CO., Inc.

Dept. 435, 4242 West 69th Street New York 23, N. Y.



get on the ball with .....

PERFORATION BALL SEALERS

Perforation Ball Sealers are engineered for superior fracturing and acidizing.

They bring to the oil industry a controlled, effective and economical treatment on ONE set-up. In wells with one-zone or multiple-zone conditions, Perforation Ball Sealers temporarily seal off the most permeable interval to divert treating fluids into the tighter zones for complete treatment.

Injected into the treating line at the well head, Ball Sealers are quick and effective, saving treatment time and expense. Ball Sealers are experienced workers, proved in wells throughout the Southwest.

Their use cuts to a minimum the multiple use of down-hole tools and ineffective chemical blocking agents. With a Perforation Ball Sealer treatment, there is minimum danger of interzone communication. Reduced differential breakdown pressure eliminates most of the stress on cement job during treatment.

Pressure logs, Radioactivity Tracer logs, and recovered balls all prove the effectiveness of Perforation Ball Sealers.

Give your well the treatment that is proved for EFFECTIVENESS, ECONOMY and SIMPLICITY — with Perforation Ball Sealers from The Western Company.

For engineered well services — logging, perforating, fracturing and acidizing — GO WESTERN!

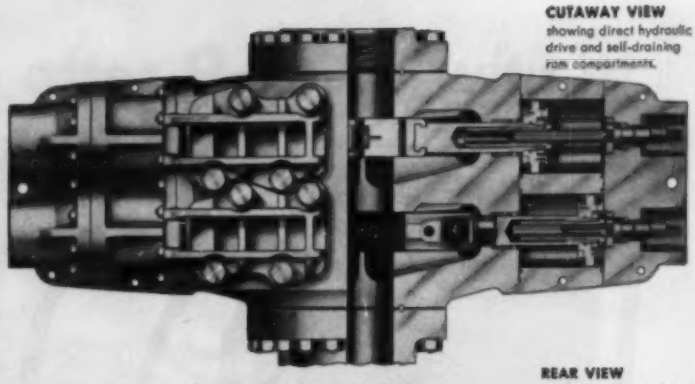
THE WESTERN COMPANY

general offices: Midland, Texas

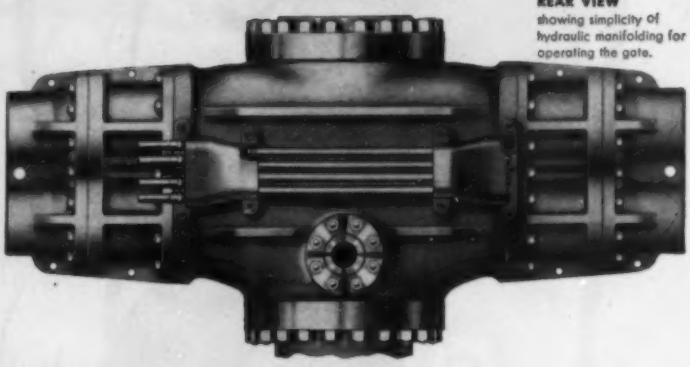
Texas: *Odessa, Seagraves, Snyder, Lubbock, Borger, Rankin* / Oklahoma: *Lindsay, Healdton, Okla. City* / New Mexico: *Hobbs* / Kansas: *Ulysses, Liberal*

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

The Cellar Control Gate Features you WANT— *YOU GET* from SHAFFER!



CUTAWAY VIEW showing direct hydraulic drive and self-draining ram compartments.



REAR VIEW showing simplicity of hydraulic manifolding for operating the gate.

Before you make your next investment in cellar control gates, take a moment to think through the various features you would like to have in those gates. You want protection, of course, but protection alone is only *part* of the story. You want such other important advantages as *Compactness . . . Simplicity of Ram Changes . . . Minimum Maintenance . . . Maximum Versatility* . . . and many others.

Then check ANY cellar control gate against the *multiple* advantages you get in Shaffer Hydraulic Cellar Control Gates and you'll see why Shaffer Gates are the top choice of leading operators throughout the oil industry. No other equipment offers *so many* design and performance features—in such a compact "package" as do Shaffer Hydraulic Gates.

For Example . . .

You get

USEABLE COMPACTNESS!

To begin with, Shaffer Hydraulic Gates are amazingly compact in all three dimensions—height, width and length. Even in sizes as large as 13⅝" (12" Series 900) Shaffer Hydraulic Double Gates require only 30" total height—Single Gates 18½".

In addition, there's no need to allow extra space above or at the ends in order to change rams, because Shaffer's exclusive side-opening doors through which the rams are changed open on the dimension where there's plenty of room. Thus, Shaffer's compactness is completely useable compactness!

You get

SINGLE or DOUBLE DESIGN

Some operators prefer Double Gates (two ram compartments unitized into one body) for their greater compactness in a multiple gate hookup. Others prefer the extra flexibility of Single Gates (use them singly . . . in pairs . . . or with a Double Gate for three-way protection). From Shaffer you get what YOU prefer—Double or Single—with both designs offering the same basic operating and construction features!

You get

EASY RAM CHANGES

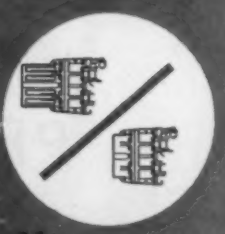
To meet requirements of varying pipe sizes as wells are drilled, the rams must be changed frequently. Shaffer Gates are unsurpassed in the ease with which the rams can be changed. Simply unbolt and open doors in the side of the gate body, slide out the ram assembly, change rams, slide the assembly back in place and bolt the doors shut. It's that simple.

What's more, rams can be changed with equal ease whether the pipe is in or out of the hole!

You get

SELF-DRAINING COMPARTMENTS

You want a gate where no detrimental mud or sand can accumulate to interfere with free ram travel—and Shaffer gives you this advantage, too. Note how the rams travel on guide ribs high above the steeply-sloped gate bottoms. Mud and sand quickly drain back into the well. Also, since well pressure is free to flow to the back of the rams, it actually assists in the closing and sealing action!



You get

RISING or NON-RISING SHAFTS

Do you prefer the quick indication of ram position provided by a Rising type of Locking Shaft? . . . Or do you prefer the greater compactness of the Non-Rising type of Locking Shaft? Take your choice—from Shaffer you can get the particular type that best meets your particular requirements!

THESE ARE ONLY PART OF THE COMPLETE SHAFFER STORY on design and operating advancements . . . advancements backed by the organization that pioneered cellar control gates more than three decades ago. Successful from the first gate built, Shaffer Gates have nevertheless gone through a continuous program of development that has kept them always ahead of the industry. That's why you get more features—plus operating flexibility to meet *your particular preferences*—when you specify SHAFFER. See your nearest Shaffer representative for further details—or write direct!

A copy of the latest Shaffer Catalog will gladly be sent on request. See the Shaffer section of your Composite Catalog.

SHAFFER

HIGH PRESSURE DRILLING AND CONTROL EQUIPMENT • FISHING TOOLS THAT EXCEL

SHAFFER TOOL WORKS: Brea, California • California Service Shops: Santa Fe Springs and Taft
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OKLAHOMA CITY, OKLAHOMA, Shaffer Tool Works, 6201 South Shields Boulevard
FARMINGTON, NEW MEXICO, Shaffer Tool Works, Post Office Box 546
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33 years OF OIL TOOL LEADERSHIP

The rugged acrobats of the oil fields

EMSCO PUMPING UNITS

...triumphs of counter-balance, weight lifting and endurance

Throughout the oil producing areas of the world, you'll find dependable, economical, easy-to-adjust EMSCO Pumping Units doing their job, day after day, month after month, year after year. Due to patented, rotary counter-weights, one man, working at ground level, can quickly, safely and easily adjust them. Precision-cut herringbone gears mounted on a rigid one-piece housing with an automatic positive lubrication system spell long service and economy. There are many sizes and styles of EMSCO Pumping Units for shallow, medium or deep pumping. Call CONTINENTAL today for bulletins and complete details.

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CONTINENTAL

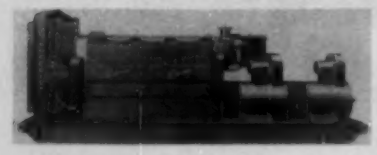
Serving the Oil and Gas Industries

CONTINENTAL SUPPLY COMPANY
A Division of The Youngstown Sheet and Tube Company
General Offices: Dallas, Texas
Representatives in all principal oil fields of the world

PT-602

NEW Drilling and Producing Equipment

(1) Diesel-Electric Rig Package. A diesel-electric drilling rig power plant featuring lower weight, more power and simplified construction has been developed.

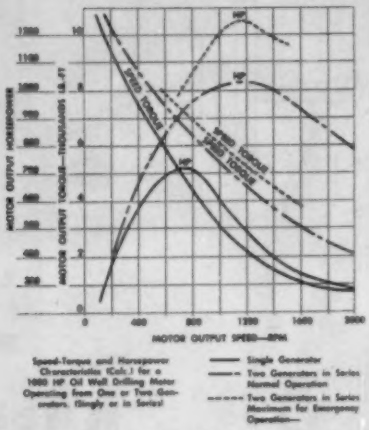


White Diesel Engine Division has designed the units for offshore or inland drilling depths over 20,000 ft.

Two models—with 6 and 8-cylinder Superior Engines—are being distributed. The engines, rated at 675 and 900 hp, are available in a choice of diesel, gas, or dual-fuel operation.

Entire package consists of two or more engine-generator sets, a minimum of three drive motors for the drawworks and two mud pumps, a console-type control stand, and a terminal cabinet to house all electrical equipment. Each engine-generator set has a Superior Engine and two generators. Engine-generator set weighs only 21 tons.

Several elements contribute to the power plants' simplified construction. They have as few as three drive motors, compared to at least six in comparable units. This is due to the fact that the Westinghouse traction-type motors in the White



Speed-Torque and Horsepower Characteristics (Calc.) for a 1600 HP Oil Well Drilling Motor Operating from One or Two Generators, Singly or in Series

—— Single Generator
—— Two Generators in Series Normal Operation
---- Two Generators in Series Maximum for Emergency Operation

packages are rated at 1000 hp continuous and 1250 hp intermittent output. In addition, the need for gears and clutches is eliminated because of direct connection of the engine and generator.

Motors are of heavy-duty, 6-pole construction. The Westinghouse generators in the units are 550 kw, d-c. Since the mud pump drives and generators are basically identical in construction, parts can be interchanged.

White Diesel Engine Division of White Motor Company.

(2) Cementing Unit. BJ Service has introduced a high-volume, high-pressure cementing and pumping unit in a cab-over design.

Rated at 510 hp, this model 111TA unit is capable of mixing and pumping 425 gal of cement per minute. Unit employs a completely new cab-over design. Complete unit weighs approximately 42,000 lb.

BJ Service, Inc.

(3) Pocket Size pH Meter. A versatile low-priced, pocket-size pH meter for acidity and alkalinity measurements that is claimed to be accurate, dependable, easy-to-operate and uses a combination elec-

trode is in production by the scientific instruments division of Beckman Instruments.

Range of the meter is from 2 to 12 pH. The single electrode combines both the reference and glass electrodes and has been especially developed for use with the new "Pocket pH Meter." The instrument also has a "memory" dial for use in standardizing.

Beckman Instruments, Inc.

(4) Plastic Well Casing. A lightweight, plastic well casing has been announced by Southwestern Plastic Pipe.

Casing is to be manufactured in a single dimension (OD-5.563 in.; ID-5.200 in.). Twenty-foot lengths are manufactured with plain end. A coupling is furnished with each joint. This material is recommended for suspension up to 300 ft. The product is not recommended as "drive" casing or as surface casing to be cemented in place and drilled through.

Southwestern Plastic Pipe Company.

(5) Drilling Mud. A class of oil-well drilling fluids that will help to open up oil reservoirs too deep to be reached by conventional drilling methods has been developed by research scientists of Socony Mobil, and is now being made available to the oil industry.

Manufactured by General Aniline & Film Corporation, products will be sold by the Antara Chemicals Division, under the trademarks DMS and DME, through regular mud supply companies.

One type of fluid, referred to as a calcium-surfactant mud, was successfully used last spring in the completion of a well to 22,570-ft and in drilling a deep Texas wildcat after encountering one of the highest bottomhole temperatures ever recorded by the oil industry above 400F.

These newly developed muds, because of their resistance to solidification at temperatures above 300 F, are expected to remove a serious limitation on the finding and development of deeper oil horizons.

In addition, the unique characteristics of the new fluids, which eliminate or minimize many of the problems encountered with conventional muds, are expected to make their use desirable in many wells of moderate bottom-hole temperatures.

Socony Mobil Oil Company, Inc.

(6) Two Oil Production Devices. Two automatic devices for the petroleum industry, developed jointly by two divisions of ACF Industries, have been announced.

These devices are: A system for automatic testing and remote recording of the production rates of oil wells, and an automatic lease custody transfer control.

Remote control system is designed to (1) automatically shuffle up to 40 wells through a flow-test cycle, one at a time; (2) collect and transmit to a central station the data on a given well, including oil, gas, and water output, gas-lift consumption, tubing pressure, time interval, gathering station number, and well number—all by remote control; (3) measure total production from a given lease, and (4) convert data onto a "common language" teletype tape that can be utilized for transmission over teletype circuits.

Automatic lease custody transfer control provides an economical means of accurate automatic measurement, sampling and transfer of oil from a producer's lease to a pipe line, unattended and on regular schedule at any hour of the day or night.

ACF Industries, Inc.

(7) Combination Spider-Elevator. Byron Jackson Tools has announced "the first combination casing spider-elevator." De-

signed for operation as either a spider or elevator, it has a safety-rated capacity of 500 tons—a rating which is claimed to be the world's largest for either a spider or elevator.

This BJ Spider-Elevator is of the slip type and eliminates the need for two separate pieces of equipment. It features unitized slips which may be manually or power operated.

First of these giant spider-elevators is now in use in the Gulf Coast region.

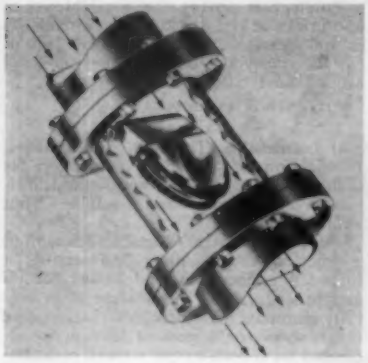
Byron Jackson Tools, Inc.

(8) Electric Tachometers. Martin-Decker has introduced a line of electric, completely self-energizing tachometers for the measurement of rotary-table speed, pump-stroke count, and engine rpm.

Advantages of these instruments are their ability to be installed at considerable distances from their take-off points, the ease at which several meters can be actuated by one generator, the lack of rotating cable which requires periodic replacement, and the ability of the meters to be calibrated to any gear ratio on the rig.

Martin-Decker Corporation.

(9) Check Valve for PVC Piping. A check valve made of polyvinyl chloride for handling corrosive gases, vapors, and



fluids has been developed and introduced by Techno.

Called Technocheck-PVC, the valve employs a unique principle used by the company in the manufacture of its metal check valves.

According to information from the company, this valve can be used in all PVC systems and installed in any position for handling salt solutions, fuels and oils, acids and alkalies, and other materials for which PVC is recommended.

Techno Corporation.

(10) Power Drive. An improved power drive is being announced by Toledo Pipe Threading. Known as the Toledo No. 68, this portable power drive has been completely redesigned for easier operation and longer life.

The No. 68, powered by a 115-v reversible a-c or d-c motor or 90-psi air motor, weighs only 33 lb.

The Toledo Pipe Threading Machine Company.

(11) Pipe Patch. Smith-Blair has announced an improved coupling for repairing misalignment breaks in water, gas, or oil pipe lines.

Called the Series 4K Flexible Cut-In Coupling, it is applicable to cast iron, asbestos-cement, or steel pipe and is installed with the pipe in place. This cut-in coupling acts as a double coupling replacing twice the length of pipe cut out.

The pipe is repaired quickly, as well as given additional flexibility. Pipe can be out of alignment over 6 deg and be repair-connected in place.

Smith-Blair.

(12) Corrosion Meter. Developed by Crest Instrument, the Corrosometer, as it is called, measures electrically the progress of corrosion in any corrosive system.

Meter is used in conjunction with special probes containing metal specimens which are subject to corrosion. Three models of the meter are manufactured: Model "C," which is a completely portable field unit; Model "K," which is designed for laboratory use and in plants, and Model "R," which is a continuous recording unit.

In use, the Corrosometer follows the progress of corrosion on the probe by measuring the loss of metal directly in microinches of penetration into the metal. Time to establish corrosion rates may be measured in hours or days rather than weeks or months because of the high sensitivity of measurement.

Crest Instrument Company.

(13) Gas Dehydrator. A gas dehydration unit featuring the use of calcium chloride pellets in a tower of patented design has been put into production by the manufacturing division of Fish Engineering.

Tests are said to have proved the dehydrator removes from 3.5 to 5 lb of water per pound of $CaCl_2$—which is from two to three times the normal removal.

There is no maintenance required aside from reloading the desiccant and changing of charts. Field tests have shown the unit will depress the dew point from 75 to 100 deg. Freeze-ups are prevented with temperatures ranging down to minus 60 F. The equipment operates at wellhead pressure, this ordinarily eliminating the presence of free oxygen which promotes corrosion.

Fish Engineering is now producing four models of the dehydrator, ranging from 2500 MCF per day with working pressure of 990 to 5000 MCF a day with designed working pressure of 660.

Fish Engineering Corporation.

(14) PVC Expansion Joint. The first slip-type pipe expansion joint of unplasticized polyvinyl chloride, according to the manufacturer, has been introduced by Tube Turns Plastics.

Expansion joint is made in 1-in., 2-in., and 3-in. sizes, and may be used with piping of smaller diameters by employing reducing bushings. All sizes allow an expansion of 3¾ in.

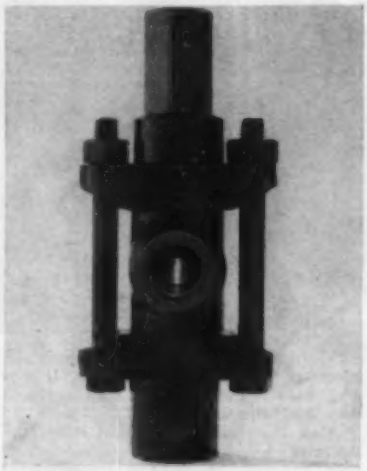
Joint is designed for use with rigidly fixed PVC piping subjected to thermal cycles. It has a neoprene "O" ring packing and is suitable for a wide range of corrosive services. Joint has been tested at pressures up to 325 psi and temperatures up to 140 F.

Tube Turns Plastics, Inc.

(15) High-Pressure Safety Valve. A safety relief valve designed to withstand pressures up to 10,000 lb per sq in. has been introduced by the fluid mechanics division of Protek Specialty.

For its size, the valve is said to have an exceptionally high capacity of liquid flow at 25 per cent over pressure. It handles air, gas, or liquid and has been fully proven under severe field test conditions.

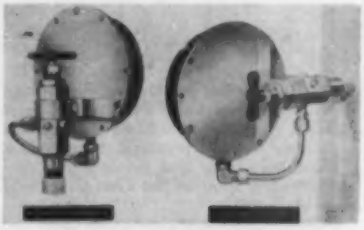
Valve has close blow down control on expansible gases and vapors. It is claimed



to be ideal for all systems handling crude oil, sour gas, and oil vapors, including hydraulic control systems, high-pressure gas systems, and high-pressure separators.

Protek Specialty Company.

(16) Small Gage-Type Valve. A gage valve of compact dimensions which incorporates safety bleeder and recorder con-



nections for sampling has been introduced by Hex Valve. Unit is designed to be exceptionally rugged and is offered in ¼ to ¾-in. sizes.

The Hex Valve Company.

(17) Visual Control Systems. A Magne-trol Control Board is said to add several advantages to visual control. It provides visual records that are more impressive and dramatic, and it provides easier and quicker methods of changing the visual record.

Magne-trol consists of a magnetic steel board which holds firmly on its surface the visual elements that comprise the needs of the user. Board can be used for production schedules, sales records and quotas, management control and analysis, graphs and charts, service schedules, inventory control, personnel records, traffic control, warehouse records, organization charts, in and out registers, and a host of other business purposes.

Methods Research Corporation.

(18) Air Compressor Lubricant. A synthetic lubricant for air compressors which minimizes explosions and receiver fires as well as carbon deposits on exhaust valves and air system piping has been announced by Monsanto Chemical's organic chemicals division.

Trademarked Pydraul AC, the lubricant is described by Monsanto as a fire-resistant fluid equivalent in lubricity to a premium-grade lube oil. Quite similar in its properties to the company's other Pydraul fire-resistant fluids, it is reportedly unique in its marked ability to reduce carbon deposition, thus offering important maintenance savings in addition to a wide safety margin in compressed air systems.

Monsanto Chemical Company.

(19) Auto Fuel Injection System. An electronic fuel-injection system that is claimed will replace a conventional carburetor on passenger cars, leading to increased power, quicker starting and warm-up periods, plus faster throttle response, has been introduced by Bendix Aviation.

The timed, self-priming system, which provides a wider latitude in fuel characteristics for high-compression engines, is called the "Electrojector." It is now ready to be adapted to engines of any car manufacturer and is said to be the first system to be developed that does not require a special drive off the engine.

Bendix officials point out that the simplified design of the Electrojector means increased power for safety, better fuel economy, quicker starts and warm-up, wider selection of fuels—another economy for the average motorist—more room under the hood, faster and livelier response to the throttle, elimination of vapor locks, and no cornering, or hill-angle effects.

Bendix Aviation Corporation.

NEW Literature

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

(20) Drilling Mud Emulsifier. An 8-page bulletin on Seeco-Mul, a drilling mud additive, has been published by Crossett Chemical. A wood products derivative, it is a comparatively new emulsifying compound widely used on the Gulf Coast and in West Texas.

Bulletin contains maintenance costs and performance comparisons of Seeco-Mul emulsifier mud systems and conventional emulsion muds, chemical analyses of the compound, and other mud engineering data.

Crossett Chemical Company.

(21) Paraffin Problem. A study covering plastic pipe and the paraffin build-up problem has been announced this week by Southwestern Plastic Pipe.

This study covers field tests using Tenite Butyrate plastic pipe in high-paraffin areas where ordinary pipe plugged quickly. Engineering reports and case histories are also included.

Southwestern Plastic Pipe Company.

(22) Bullet Perforator. An 8-page bulletin featuring results obtained with the improved M-3 Bullet Perforator is now available, according to McCullough Tool announcement.

Bulletin describes 13 actual perforating jobs performed under all types of conditions in the United States and Canada. The versatility of the M-3 Bullet Gun and its capabilities under varied operating conditions is shown in this collection of recent job reports.

McCullough Tool Company.

(23) Wellheads. All National wellhead equipment is cataloged in a bulletin newly issued by National Supply. The 20-page booklet gives specifications and design features of equipment for the whole range of well depths and pressures. Illustrated instructions for "triple-sealing" a wellhead are included.

The National Supply Company.

(24) Rust Preventives. Valvoline now has available a 16-page booklet explaining how to solve the problems of rust with Valvoline Tectyl Rust Preventives and Rust Removers. Chapters are devoted to: The Problem of Rust, Cleaning the Product, Materials in Corrosion Preventives, and How to Choose a Rust Preventive.

Valvoline Oil Company.

(25) Swaged Assemblies of Wire Rope and Fittings. Announced by Macwhyte is a catalog of many swaged wire rope assemblies. This 24-page catalog gives all dimensions, drawings, capacities, and sizes of both terminals and wire rope. It is called "Industrial Standards Macwhyte's 'Safe-Lock' Wire Rope Assemblies."

Macwhyte Company.

(26) Full-Flow Valves. A 4-page bulletin dealing with eight types of Coppus Sentry Full-Flow Valves is now available from Coppus Engineering. Bulletin covers in considerable detail the design, function, and specifications of these advanced valves.

Coppus Engineering Corporation.

(27) Lapping Compound. Timesaver Products has published a 24-page, illustrated booklet which outlines in detail money-saving methods of fitting bearings, gears, slides, pistons, etc., with Timesaver Lapping Compound.

Timesaver Lapping Compound is claimed not to charge or imbed into metal surfaces or continue to cut.

Timesaver Products Company.

(28) Diaphragm Valves. A two-color, 12-page catalog featuring Hills-McCanna Diaphragm Valves has been released by the company.

This catalog describes Hills-McCanna diaphragm valves in terms of their advantages, applications, and specifications. The three basic types of valve operations are shown and dimensional specifications are given. Information is also included on plastic bodies and diaphragms.

Hills-McCanna Company.

(29) Forging and Casting Divsion. A 30-page catalog on the forging and casting division of Allegheny Ludlum is now being distributed by the company.

Catalog gives complete data on smooth hammered forgings, composite die sections, cast-to-shape tool steels, and a new steel finder, which gives detailed information on the various forging and casting steel grades made by this division.

Allegheny Ludlum Steel Corporation.

(30) Wellhead Dehydration and Hydrocarbon Recovery. A 23-page brochure on the operation and engineering of the type DAU units has been released by Parkersburg Rig and Reel. This bulletin contains an engineering discussion and comparison of the company's new desiccant-type adsorption units with conventional separation, low-temperature separation, and refrigeration units. Also data are provided to assist in the application of these DAU units.

The Parkersburg Rig and Reel Company.

(31) Building and Accessory Line. A colorful catalog detailing Stran-Steel's newly enlarged line of industrial and commercial buildings and accessories has been published by the corporation. Prominently featured in the large, illustrated brochure are Stran-Steel's completely new series of rigid frame structures, two 50 and 60-ft bow-string truss buildings and the recently developed Stran-Satin metal wall.

Stran-Steel Corporation, a unit of National Steel Corporation.

(32) How American Standards Are Made. This booklet describes the three ways standards become nationally accepted and approved as American Standards. It tells who makes these American Standards and why, and who uses them.

Also the booklet explains why the American Standards Association exists, how it guards the democratic processes through which American Standards are developed, and how it operates impartially for the manufacturer, the consumer, and the general public.

American Standards Association.

(33) Plastic Rod and Tube Stock. A 24-page, two-color catalog on plastic rod and tube stock has been issued by Friedrich & Dimmock.

Publication covers the available sizes and prices of rod and tube stock made of crystal clear methyl methacrylate, Teflon, cast acrylic, vinyl, polyethylene, cellulose acetate, and polystyrene.

Friedrich & Dimmock, Inc.

(34) Lubricating Threaded Connections. Lubrication of threaded connections is featured in the second issue of the Lubrication Newsletter now available from Alpha Molykote.

Lead article is a technical description of the causes of galling and seizing in threaded connections and power screws and procedures for lubrication to practically eliminate these problems. Descriptive charts show coefficients of friction as calculated from both torque wrench measurements and test data using a threaded assembly.

The Alpha Molykote Corporation.

(35) Diesel Engines. An illustrated brochure describing General Turbopower Diesels has been issued by the Detroit Diesel Engine Division. Specifications of industrial and marine models ranging from 159 to 300 bhp are fully described along with features of design and performance data.

Detroit Diesel Engine Division, General Motors Corporation.

(36) Tube Expanders. Thomas C. Wilson has published a catalog about tube expanders and associated tools used for tube rolling. In the illustrated, 119-page catalog, special sections are devoted to expanders, general accessories, measuring instruments, rollers, extensions, and drives.

Thomas C. Wilson, Inc.

(37) Data System. A 16-page brochure describing the Beckman Model "111" Data System is now available from Beckman Instruments.

Digital control of the system is accomplished through use of the Beckman Pinboard Programmer—a device which eliminates "knob-twiddling," time-consuming calibration, and re-engineering to accommodate changes in process requirements.

Beckman Instruments, Inc.

(38) Pocket-Size Thread Gage. Now available from Pittsburgh Pipe & Coupling is a pocket-size thread gage. Gadget identifies threads from 8 to 14 per inch, round or sharp, external or internal. Gage is only 6¼ in. long and made of hard-surface laminated plastic.

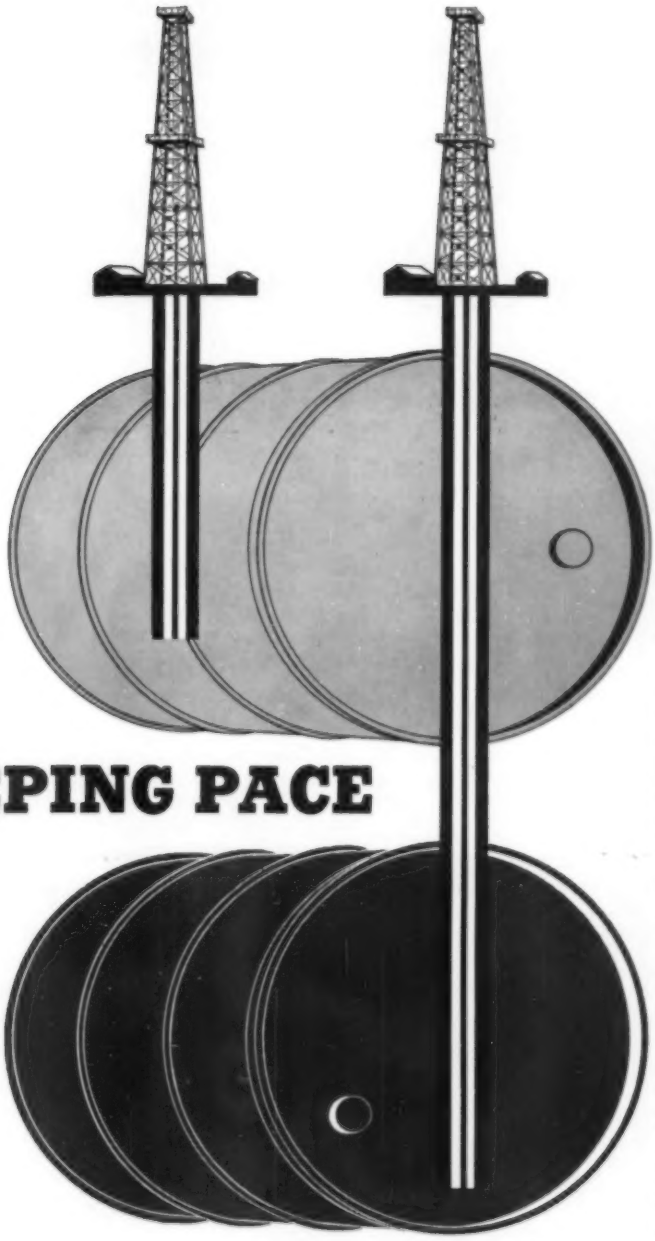
Pittsburgh Pipe & Coupling Company.

(39) Lubrication Spray Equipment. An eight-page brochure on its spray lubrication systems for open gearing and slide surfaces has been issued by Farval. The three-color, illustrated booklet offers descriptions of manual and automatic systems and component equipment.

The Farval Corporation.

(40) Blower. A four-page, two-color, bulletin (newly revised) on the "Standardaire" blower, a modern compressor adaptable to either pressure or vacuum service. The Standardaire will handle air, gas, or vapor, as modified for each particular service.

Read Standard Corporation.



KEEPING PACE

Drills were chewing their way down for about 2000 feet in the search for oil in 1916. Today's drilling depth is more than double that.

The change in drilling that forty years has brought well symbolizes many advances in the petroleum and chemical industries. Engineers have dug more deeply into the secrets of nature, too . . . have designed plants and processes to wrest new products and services from petroleum, ores and elements.

We mentioned 1916 because that is the year Sun Ship was founded. It has long served the swift-growing needs of petroleum and chemical industries. Year by year, the engineering skill and facilities of the great Sun Ship plant have proven their ability to meet the demands for plant and equipment keyed to the swift pace of progress in these and other important fields. Sun Ship keeps pace with progress.

Sun

SHIPBUILDING & DRY DOCK COMPANY

SINCE 1916

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TECHNIQUES *and* TOOLS

MAKE THE DIFFERENCE IN WESTERN HEAT EXCHANGERS

The manufacture of Western heat transfer equipment is characterized by two important factors: (1) employing the latest and best data available in establishing the actual needs of our customers quickly and accurately; (2) employing the same care and attention to detail in the fabrication of the equipment required.
Western Supply Company renders a *complete service* to each customer — research, design, engineering and fabrication — resulting in equipment of exceptional quality at a fair price, and built for long-life economy.
Your heat transfer requirements — present or future — deserve the attention of Western *specialists* in this field. We'll appreciate your inquiry.

In the *thermal rating* of heat transfer requirements, Western engineers have developed a technique which is actually a *consulting service,* working closely with customers to arrive at the best and simplest solution of their needs.

Thus, each Western exchanger is sized to give the most economical unit for the job, and reflects the experience gained in working equally closely with other customers with similar problems.

The Western "technique" also recognizes the importance of completing your heat exchanger file quickly, thereby allowing you to proceed with other operations.

For instance, when standard floating head, U-tube or fixed tube sheet exchangers are ordered from Western, you can depend on receiving drawings *within 7 to 10 days,* enabling you to proceed with piping and foundation drawings immediately.

In the fabricating stage, Western uses only the most modern production tools and equipment, assuring the utmost in production control in the building of your heat exchangers. Such quality controls as controlled torque tube rolling, weld x-ray, Magnafluxing and hydrostatic testing assure the consistent high standard of Western exchangers.

ASME code standards represent the *minimum* requirement for Western heat exchangers, but on *each* unit, Western builds the *best heat exchanger possible.*

Thus, in the instance of careful tube hole preparation and controlled torque tube rolling, a given Western Exchanger can be retubed more often for greater savings for our customers, because of these high standards of production.

Techniques and tools *do* make a difference in thermal and mechanical design — and the difference is in your favor at Western!

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HEAT EXCHANGERS

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P. O. BOX 1888 • TULSA, OKLAHOMA

HUDSON-RUSH COMPANY — 753 Gladstone Blvd., Shreveport, La.
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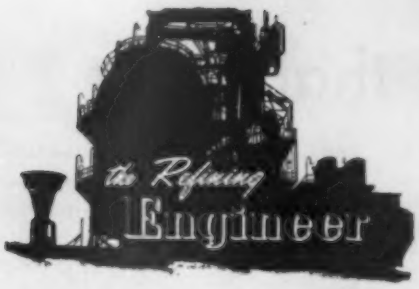
P. O. Box 3151, Amarillo, Tex.

PROCESS INSTRUMENTS & EQUIPMENT CO. — North Bldg., Charleston, W. Va.

H. W. SEVERANCE — 2416 Frankfort Ave., Louisville, Ky.



exclusive | part 1

In catalysts, in lubricants, and in alloy steels, the use of molybdenum is growing, and for good reason

MOLYBDENUM In Petroleum Refining

Benjamin H. Danziger and J. Richard Milliken
Climax Molybdenum Company

THE versatile element molybdenum is one of the refining industry's most important materials in three forms—in catalysts, as an alloying agent for steel equipment, and as a lubricant additive.

Though these three principal uses for molybdenum in refining are unrelated in function, in each case molybdenum or a molybdenum compound is selected because of its superior performance under extreme service conditions. And because of this common characteristic, it is not unusual to find molybdenum performing all three functions in one unit.

In the case of a catalytic reformer, for example, a molybdenum catalyst may be selected for its excellent resistance to poisons, a molybdenum steel alloy may be used in equipment to impart strength at elevated temperatures, and molybdenum disulfide may be applied to reactor bolts to permit easy disassembly after long exposure to high temperatures.

In addition to their wide applicability arising from this property of performing well under difficult conditions, molybdenum materials have something else in common — their use by the petroleum industry is rapidly expanding so that in the past 5 years, refining and petrochemical processes have taken a leading place among the largest volume users of molybdenum.

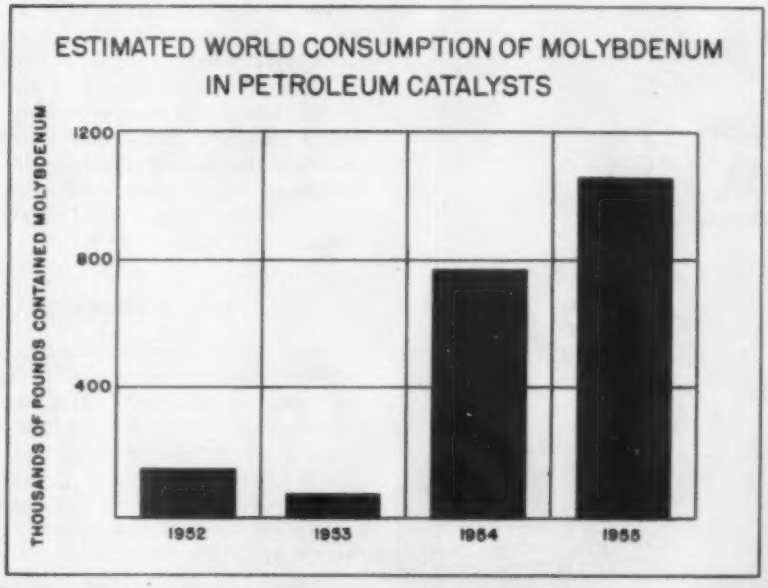


FIG. 1. Estimated world consumption of molybdenum in petroleum catalysts.

Catalysts

One look at the figures for consumption of molybdenum (Fig. 1.) in the manufacture of catalysts, and it is readily apparent that the importance of this catalytic element to the refining industry is great and growing. Molybdenum used in catalysts has increased five-fold over the past 3 years, a growth due mainly to its wide expansion in catalytic reforming and catalytic desulfurization.

In 1952, world-wide consumption of molybdenum for catalysts totaled 200,000 lb. At the end of last year, this figure grew to an estimated 1,200,000 lb. Of 1952's 200,000 lb, some 130,000 lb are estimated to have gone into desulfurizing and reforming catalysts, the latter type accounting for most of this consumption. Of last year's total, 850,000 lb went into reforming catalysts and 200,000 lb into desulfurization catalysts. An estimate of the market in 1960 puts the figures for reforming and desulfurizing catalysts at 1,200,000 and 750,000 lb, respectively, of contained molybdenum.

This rapid growth, both realized and forecast on the basis of current technological trends, is a reflection of the drive for high-octane gasoline, the demand for products of low-sulfur content, and the necessity of processing high-sulfur crudes.

Molybdenum, a transition element with the incomplete inner shell of electrons needed for catalytic activity, catalyzes the chemical reactions common to reforming processes for octane improvement and those that take place in desulfurization methods. These molybdenum catalysts, moreover, are generally resistant to common catalyst poisons.

Desulfurization

Catalytic desulfurization processes,

How to make octanes that count

by F. D. BUERSTETTA
Ethyl Corporation, Detroit, Mich.

Manufacture of high-octane gasolines to meet today's and tomorrow's automotive demands is putting increasing pressure on the refiner. Meeting these demands requires that the available hydrocarbon components in the refinery be blended to best advantage to give maximum performance on the road.

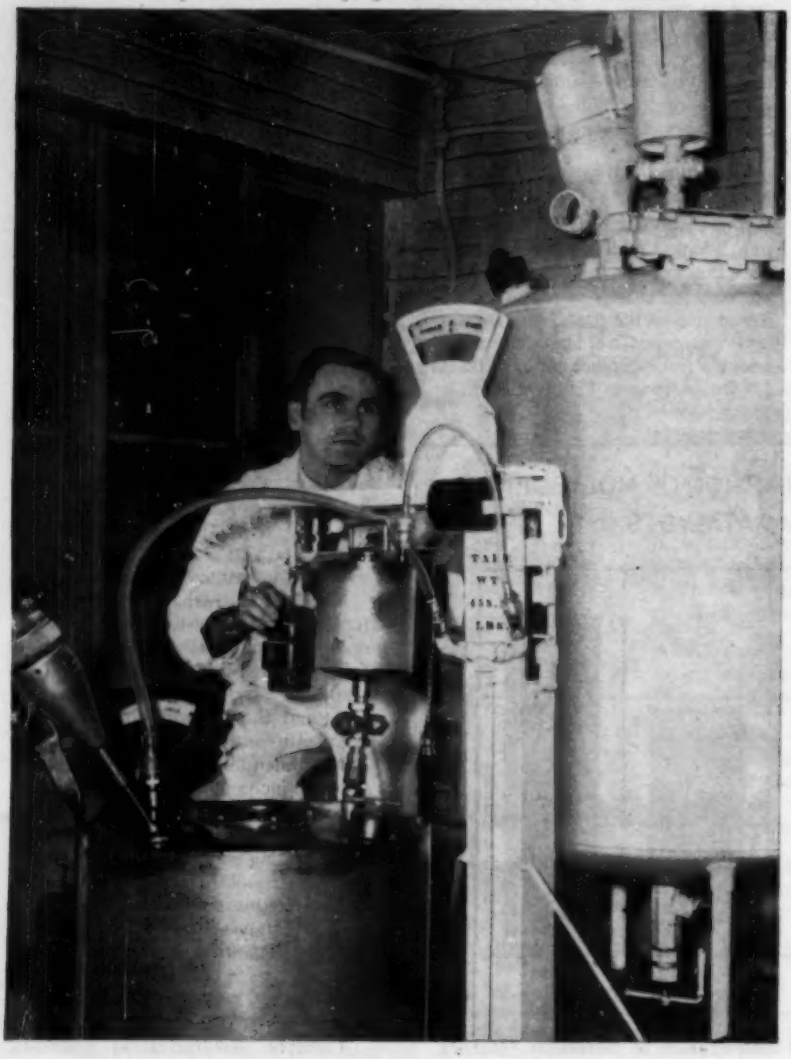
Each octane number at the 100 octane level may cost as much as 15 to 20 cents per barrel. Thus, there is a marked incentive for insuring that each laboratory octane number, obtained at this great expense, provide corresponding antiknock performance in cars on the road.

Hydrocarbon blends studied

As part of a continuing Ethyl Research program to establish the fundamentals of laboratory versus road antiknock quality, a study was conducted not long ago in which the behavior of blends of pure C_7 and C_8 hydrocarbons was examined.

Within this C_7-C_8 range, the four basic hydrocarbon types—olefins, paraffins, naphthenes and aromatics—were blended in varying proportions. Actually, a mixture of iso-octane and *n*-heptane was used as the paraffin constituent to permit maintenance of a constant Research octane number while investigating the effects of tetraethyllead concentration and variations in hydrocarbon-type composition. Toluene, di-isobutylene and methylcyclohexane were selected to represent the aromatics, olefins and naphthenes, respectively. Each of these hydrocarbons was blended in concentrations of 20, 40 and 60 per cent by volume with the proper paraffin mixture, giving nominal Research octane levels of 92, 96 and 100 at each of four tetraethyllead concentrations—0.0, 0.5, 1.5 and 3.0 ml. per gallon.

FIGURE 1. Accurate blending of pure hydrocarbon components at Ethyl Laboratories is the first step in the research program described in these columns.



Each blend was evaluated in laboratory test engines and was then rated in the 9-to-1 compression-ratio engine of a 1955 passenger car equipped with an automatic transmission. Ratings were made by both the Modified Uniontown and Modified Borderline techniques.

The results of that study were reported in detail in "Octane Possibilities with C_7-C_8 Hydrocarbons," copies of which are available on request to Department 32, Ethyl Corporation, 100 Park Ave., New York 17, New York. In general, it was shown that, on the basis of road appreciation (road rating minus Research method rating), highly leaded blends generally outperformed other blends of equivalent R. O. N., especially at high engine speeds.

New data available

Now, a second report in this series entitled "Octanes That Count" is available for your study. This new report compares the various toluene-paraffin blends and di-isobutylene-paraffin blends. Two 1955 passenger cars were used in this study and some interesting data on the effects of vehicle type were obtained.

These cars had V-8 engines of nomi-

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

FIGURE 2. A test vehicle on the chassis dynamometer engaged in making one of the hundreds of road octane determinations reported in this Ethyl study.

nal 9.0-to-1 and 8.5-to-1 compression ratios and were selected because these engines represent extremes in fuel-rating characteristics.

In order to bracket the maximum octane-number requirement of the two cars used in the study, the test blends were formulated at three different Research octane number levels. Road ratings obtained at these octane-number levels permitted an estimation of the Research quality of a blend which would just satisfy the antiknock requirements of a vehicle at any engine speed. Comparisons of fuel behavior made in this manner eliminate the possibility of obtaining ratings at overly advanced or retarded spark settings. It is believed that a study of this type provides a realistic appraisal of the relative merits of hydrocarbon type and TEL concentration.

Conclusions

Based on the Research octane number of fuels required to give knock-free operation at various engine speeds under normal conditions, the following generalizations can be made:

1. At high engine speeds (3000 RPM):
   a. Toluene-paraffin blends are superior to di-isobutylene-paraffin blends of equivalent hydrocarbon insert concentration and TEL level in both cars tested.
   b. The Research octane number of fuels required to satisfy either car, regardless of hydrocarbon type and concentration, decreases at higher TEL concentrations.
2. At low engine speeds (1000 RPM):
   a. Toluene-paraffin blends and di-isobutylene-paraffin blends are, in general, equally effective in meeting the vehicles' antiknock requirements. Exceptions are the blends with high concentrations of both TEL and hydrocarbon inserts. For these conditions, the toluene-paraffin blends excelled in one car and were slightly inferior in the other.
3. As the concentration of either toluene or di-isobutylene is increased in blends at any given TEL level, the Research octane number of blends required to satisfy one vehicle increased—and the octane number required to satisfy the other vehicle decreased. Thus, highly paraffinic blends showed superior performance in one car and inferior performance in the other used in this test.

How Ethyl Research can help you

At today's high octane levels, the art of blending hydrocarbons has taken on more and more importance. As a service to the oil industry, Ethyl Research has launched a hydrocarbon blending program of its own to complement the intensive effort which the industry is devoting to this problem.

We are now testing many new blends in our laboratories and in high-compression engines on the road. Much of the data from these tests is being interpreted in terms of "road appreciation" to give refiners a better idea of the effectiveness of each blend. Write Department 32, Ethyl Corporation, 100 Park Ave., New York 17, New York, for a copy of "Octanes That Count"—another in the continuing series of reports from the Ethyl Corporation on fuel blending and other studies of vital interest to refiners today.

For further information, just call your Ethyl Representative. He'll be happy to arrange an appointment for you with one of our Technical Representatives.

ETHYL CORPORATION
New York 17, N. Y.

ETHYL ANTIKNOCK COMPOUND — ETHYL CORPORATION

Research Laboratories:
1600 W. Eight Mile Road, Ferndale 20, Mich.
2600 Cajon Road, San Bernardino, Calif.

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FIG. 2. New hydrodesulfurization unit in Shell's Stanlow, England, refinery.

which are mild selective hydrogenation methods for removing sulfur compounds from petroleum distillates, have come into wide-scale use with the availability of low-cost by-product hydrogen from catalytic reforming installations. These permit processing of stocks as high as 3 to 4 per cent in sulfur content to obtain products with as little as 0.01 per cent sulfur without the product losses experienced with extraction methods.

Molybdenum compounds are particularly well suited to the demands of such processes, since they are extremely effective in rupturing the carbon-sulfur bond in both cyclic and straight-chain compounds. Almost all of the recent processes use cobalt molybdate catalysts, generally containing about 10 per cent molybdenum oxide and about 1 per cent cobalt oxide supported on alumina or bauxite. These catalysts are especially resistant to poisoning by sulfur, nitrogen, metals, and salt contaminants, and they withstand calcining when regenerated at high temperatures. Moreover, they selectively hydrogenate diolefins without touching the benzene ring. Thus, gum-forming diolefins may be eliminated without wasteful saturation of aromatics to naphthenes.

Such compounds as thiophenes, thiophanes, thioethers, organic sulfides and mercaptans are converted into hydrogen sulfide and hydrocarbons. The carbon-nitrogen bond in organic nitrogen compounds is also broken, and the nitrogen removed as ammonia.

Catalytic desulfurization processes are applied to a variety of stocks ranging from naphthas to crudes. Operating temperatures are generally about 750 F. Above 900 F, catalyst activity falls off rapidly. Pressures vary according to the process from about 100 to 850 psi. Under these conditions, liquid recoveries are almost 100 per cent by weight and over 100 per cent by volume.

Among the different processes for catalytic desulfurization using molybdenum catalysts are Autofining, Unifining, Hydrobon, Hydrofining, and Hydrodesulfurization, such as the "Trickle" process.

Autofining: This process, developed by British Petroleum Company, Ltd., is featured by production of the hydrogen necessary for desulfurization by the dehydrogenation of naphthenes in the feed stock to aromatics. In a sense, the process is in between reforming processes and other catalytic desulfurization methods that require added hydrogen for conversion of sulfur to hydrogen sulfide. It can be applied to straight-run distillates up to 700 F end point, aromatic extracts and blends with cracked distillates.[1]

The catalyst used in the three commercial Autofining installations is of mixed cobalt and molybdenum oxides on alumina. Hydrogen sulfide does not have to be removed from the recycle gas, and the catalyst can be easily regenerated to full activity with steam-air or inert gas-air mixtures. Frequency of regeneration varies from about every 200 to 400 hr for heavy feed stocks like diesel oils, to 800 to 1000 hr for lighter feeds like kerosines and virgin light gas oils.[2]

With such a catalyst, adequate desulfurization of tractor fuels containing up to 0.6 per cent weight sulfur has been accomplished at a pressure of 100 psi, temperature of 780 F, recycle rate of 2000 standard cubic feet per barrel and space velocities of 1 to 5.[2]

Attempts to autofine high-sulfur (1.0 to 1.3 per cent) diesel oils from Middle East crudes under these conditions, however, have been unsuccessful. The aim was to produce a diesel fuel with a maximum sulfur content of 0.1 per cent, but only 50 per cent desulfurization could be achieved. Since sufficient improvement could not be obtained by modifying process conditions, a better catalyst was sought. A new catalyst has been developed that, in conjunction with improved processing methods, gives a product with only 0.1 per cent sulfur from feedstuffs containing up to 1.3 per cent weight sulfur.[3]

This new autofining catalyst is also of the cobalt and molybdenum on alumina type, but it is activated with **fluorine.** Its finished form can be either granular or pelleted, and it has good physical properties making for long service life.

Regeneration of the catalyst is carried out with once-through or hot-cycle inert gas-air mixtures. However, a small amount of fluorine is lost from the catalyst during regeneration due to hydrolysis of some of the metallic fluorides by water formed in combustion of carbonaceous deposits. Adding organic fluorides or hydrogen fluoride to feed stock or recycle gases makes up for this loss, restoring the catalyst to full activity after regeneration.[3]

Based on the successful operation of a 12 bbl/day pilot plant, the following operating conditions would produce a product with 0.1 per cent weight sulfur from a feedstock containing 1.25

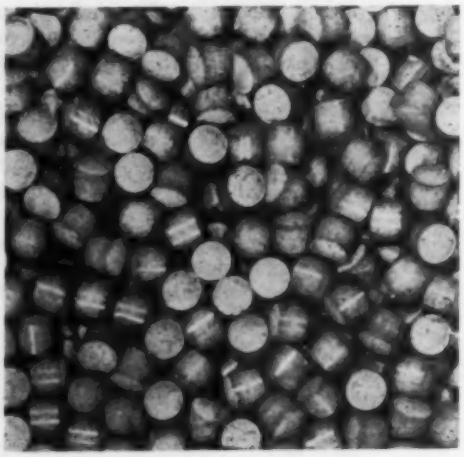

FIG. 3. View of typical hydrodesulfurization catalyst, containing molybdenum.

—Courtesy, Girdler Corporation

per cent weight sulfur in a large commercial plant: Temperature of 800 F, space velocity of 1, pressures of 600 psi (maximum) and 100 psi (minimum), and recycle gas rate of 10,000 (at 600 psi) and 2000 (at 100 psi) SCF per barrel.[3]

Unifining: Of catalytic hydrogenation processes, Unifining,[4] which is licensed by the joint developers, Universal Oil Products Company and Union Oil Company of California, is one of the most versatile and widely used. Applicable to a wide variety of distillate stocks, it removes sulfur, nitrogen and metallic contaminants, and, in the case of cracked stocks, also saturates diolefins and decomposes oxygen compounds to improve stability of the product. The hydrogen consumed in these reactions, unlike Autofining, is supplied from an outside source, generally by-product hydrogen from catalytic reformers.

Process conditions, of course, will vary with the particular feedstock and the desired product. In general, however, operating conditions are below 1000 psi and 800 F.

The catalyst, which promotes the desired reactions while suppressing unwanted side reactions, contains cobalt and molybdenum on alumina support. It is generally used in the form of cylindrical pellets, and these are quite rugged in service. It is relatively unaffected by the known catalytic poisons found in charging stocks, recycle gases and regeneration gases, and is extremely stable at temperatures considerably higher than those likely to be encountered. The interval before regeneration is necessary varies with the charge and process conditions, and, depending on these factors, may be a year or more. Simple combustion of the catalytic coke accomplishes regenerations if and when necessary.

Effectiveness of Unifining in sulfur removal is shown by the following data for straight-run naphthas: Kuwait source, charge with 0.078 per cent weight sulfur reduced to 0.0011 per cent; West Texas source, charge with 0.15 per cent weight sulfur reduced to 0.0016 per cent, and California source, charge with 0.141 per cent weight sulfur reduced to 0.0022 per cent.

Hydrobon: Union Oil Products original process was called Hydrobon and the company licensed only one unit under the name before it was colicensed with Unifining.

Hydrofining: This Standard Oil Development Company process is second to Unifining in extent of application,[5] with a large number of units in operation or under construction in the U.S., Canada and Europe. Like Unifining, it is quite versatile and is used to desulfurize and otherwise improve the quality of many types of stocks — gas oils, virgin or cracked naphthas, lube oils, waxes, middle distillates, etc.

Cobalt and molybdenum oxides on alumina are effective for most purposes, but other catalysts are reportedly better for different operations.[6] In two installations for improving the quality of low-cost lubricants, the catalysts are identified as modified molybdena on alumina.[7] This type catalyst was selected for these units on the basis of cost, availability, strength and decolorizing and desulfurizing activity. In these units, operating conditions are such that a catalyst life sufficient to permit treatment of at least 50,000 bbl of oil per ton of catalyst can be expected.

"Trickle" Hydrodesulfurization: This catalytic hydrogenation process, developed by Royal Dutch-Shell, gets its name, "trickle process," from the fact that the liquid charge, together with hydrogen, trickles downward as a thin film through a fixed catalyst bed. With it, 85 to 90 per cent sulfur removal is possible at low hydrogen recycle rates, permitting savings in operating and capital costs since size and power consumption of compressors are reduced, and less heat-transfer equipment is needed.

A large variety of high-sulfur stocks, such as straight-run and catalytically cracked gas oils and shale oil, can be treated. High-boiling fractions can be economically upgraded since vaporization is not necessary in this process. This process offers promise for the direct treatment of high-sulfur crudes. Only the reaction between hydrogen and sulfur should be promoted; hydrogenation of aromatics and other side reactions should be suppressed. The catalyst best meeting these requirements on the Shell Hydrodesulfurization process contains 0.8 parts cobalt, 6.5 parts molybdenum and 100 parts bauxite carrier. It is prepared by impregnating the carrier with a cobalt-nitrate and ammonium molybdate solution (containing cobalt and molybdenum in an atomic ratio of 1 to 5). Catalyst life is of the order of a year, with complete regeneration **in situ** possible.[8]

In a reactor, there will normally be a number of catalyst beds so that cold charge oil can be injected between beds to take up heat of the exothermic hydrogenation reaction. The number of beds will depend upon the sulfur content of the feed and the degree of desulfurization desired.

In the Shell hydrodesulfurizer at the Stanlow (England) refinery,[9] the reactor has 25 metric tons of catalyst over six beds. In processing light catcracked cycle oil at feed rates of 7000 bbl/day, over 90 per cent desulfurization was achieved. The cobalt-molybdenum-alumina catalyst gave very little hydrogenation of aromatics at this high degree of sulfur removal.

Catalytic Reforming

Catalytic reforming, developed at the start of World War II to supply toluene for TNT and aromatics for aviation gasoline, is the fastest growing refinery process. From an estimated U. S. capacity of 125,000 bbl/day in 1951, capacity at the end of last year is estimated to have increased to about 1,000,000 bbl/day, and by 1960 is expected to reach 1,700,000 to 1,800,000 bbl/day.[10, 11] The current boom in this process is primarily in response to the continual demand for high-octane gasoline for high-compression automobile engines.

Molybdic oxide on alumina was the catalyst developed for these first catalytic reforming units, and molybdenum catalysts have increased in importance in the refining industry with postwar extension of the process. Reforming catalysts now represent the largest single market for molybdenum chemicals and the largest single nonmetallurgical use for molybdenum.

The Authors

B. H. Danziger

J. R. Milliken

Benjamin H. Danziger has been manager of the catalyst and pigment development division of Climax Molybdenum Company, New York City, since 1954, after having served as assistant budget officer for that company for two years. Prior to this experience, he was active with the Ruberoid Company in the development and production of building materials in which that company is interested. He attended Massachusetts Institute of Technology and received a master's degree from the Harvard Graduate School of Business Administration in 1952.

J. Richard Milliken holds a BS in metallurgical engineering from the University of Pittsburgh. A specialist on the process industries and petroleum refining, he was previously employed by the United States Steel Corporation. At Climax Molybdenum Company, he is in charge of development of molybdenum alloys in the process industries.

The principal reactions that take place in catalytic reforming are the following, all of which results in octane improvement:[12]

1. Dehydrogenation of cyclohexane and its homologues to aromatics.

2. Dehydrocyclization of straight-chain aliphatics of at least 6 carbons to aromatics.

3. Dehydroisomerization of cyclopentane and its homologues to aromatics.

4. Isomerization of normal paraffins to branch-chain products.

Other secondary reactions that also occur are paraffin hydrocracking, aromatic hydrogenation, olefin saturation, dehydrocyclization of olefins, polymerization, dehydrogenation of paraffins and naphthenes to olefins, isomerization of olefins and naphthenes, and desulfurization.

Since feed stocks contain varying mixtures of compounds, these reactions all occur simultaneously. The particular charge stock, process conditions, and catalyst condition will determine the relative extent of each reaction in any given operation.

Catalytic reforming is generally carried out on virgin naphthas, but the range of feed stocks may be widened to include such materials as cracked naphthas, coker and cracked gasoline, and natural gasoline.

With molybdenum catalysts, temperatures of 870-1000 F and pressures of 100 to 400 psi are required. High hydrogen partial pressure in the reactor keeps the dehydrogenation activity of the catalyst high and prevents deposition of decomposition products on the catalyst.

Under these conditions, which vary with the particular process and installation involved, molybdenum compounds are particularly effective in catalyzing the four principal reforming reactions mentioned above, while suppressing undesirable reactions. In addition to this basic requirement of high, selective catalytic activity, molybdenum compounds have the advantages of outstanding resistance to poisoning, comparative low cost and adaptability to fluid-bed processes with continuous catalyst regeneration.

Pretreatment of feed stocks to remove undesirable compounds is unnecessary with molybdenum catalysts.[10] Olefins, for example, must be hydrogenated to paraffins before reforming with platinum catalysts, but not when molybdenum catalysts are employed. Similarly, stocks containing such contaminants as sulfur, nitrogen, lead, arsenic and copper compounds must be pretreated to remove or reduce them to an absolute minimum before charging platinum catalyst reformers. But molybdenum catalysts have a high tolerance for these common catalyst poisons, and prior removal is unnecessary. High-sulfur stocks can be treated readily with molybdenum catalysts, with the sulfur removed from the catalyst during regeneration — as SO_2 in fluid reforming and as H_2S in fixed-bed reforming.

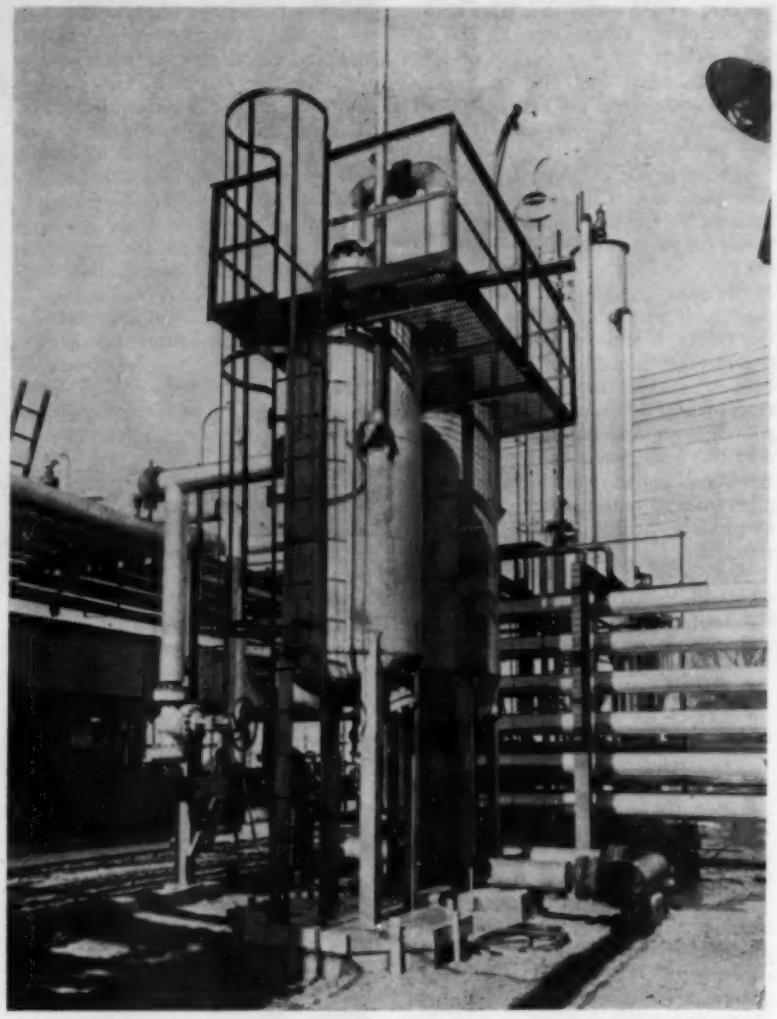

FIG. 4. The first desulfurization Unifiner built in this country, United Refining Company, Warren, Pennsylvania.

Molybdenum catalysts are inexpensive, a factor which, together with their ability to be continuously regenerated, makes it feasible for the refiner to enjoy the advantages of fluid-bed reforming. Regeneration of molybdenum catalysts, as practiced in fluid-bed processes, continuously removes catalyst contaminants and restores the compound to a state of high catalytic activity. With more expensive catalysts, the greater catalyst losses inherent in the technique mean prohibitively high operating costs for make-up catalyst.

Moreover, as the push for high-octane products is reflected in the use of more severe conditions of temperature and pressure, continuous regeneration becomes of increasing value. For under these conditions, catalyst fouling is much greater, and optimum processing conditions cannot be maintained without continuous restoration of catalyst activity. It is difficult to generalize, of course, on the relative economics of continuous fluid-bed and cyclical fixed-bed processes, but certainly in large-scale installations, the processes that permit continuous operation at peak catalytic performance should be more economical.

End of Part I

Conclusion to appear in an early issue

EXCLUSIVE

Heat Exchanger Cleaning System

New machine and routine simplifies cleaning, reduces cost, 'downtime'

For external cleaning, bundles are placed on these four-wheel carts (two in tandem), resting on rollers for easy turning while being cleaned.

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Maintenance Engineer, Richfield Oil Corporation

C. A. Faulconer
Master Mechanic Richfield Oil Corporation

DURING the 1952 expansion program at Richfield Oil Corporation's Watson, California, Refinery, new shops and warehouse facilities were installed. A part of these facilities was the new heat-exchanger bundle cleaning section located adjacent to the east side of the main shops building.

This area is serviced by a 10-ton overhead crane, which also serves one bay of the shops building and extends out some 200 ft over the open cleaning area. Practically all exchanger bundles in the refinery units requiring cleaning on both tube and shell sides are removed and delivered to this central cleaning area by a Ross gantry truck. Following cleaning and hydrostatic testing, they are returned to their units and placed back into service.

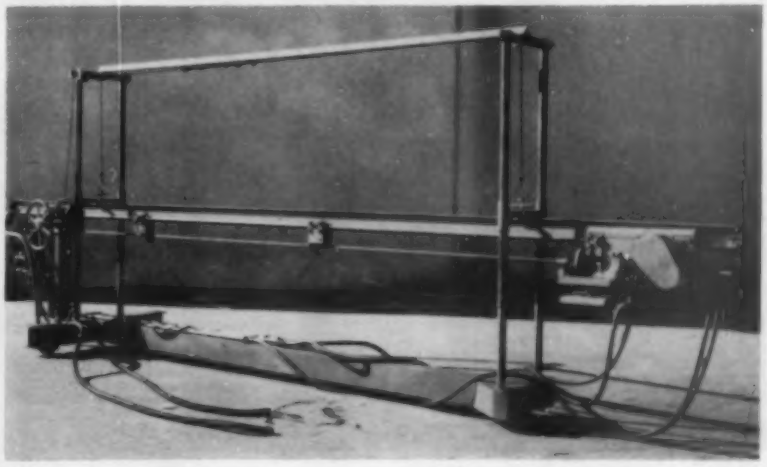
There are a total of approximately 600 exchangers in service in the refinery; therefore, the cleaning and repair of the bundles is a major part of an operating unit turnaround.

Shellside of Bundles

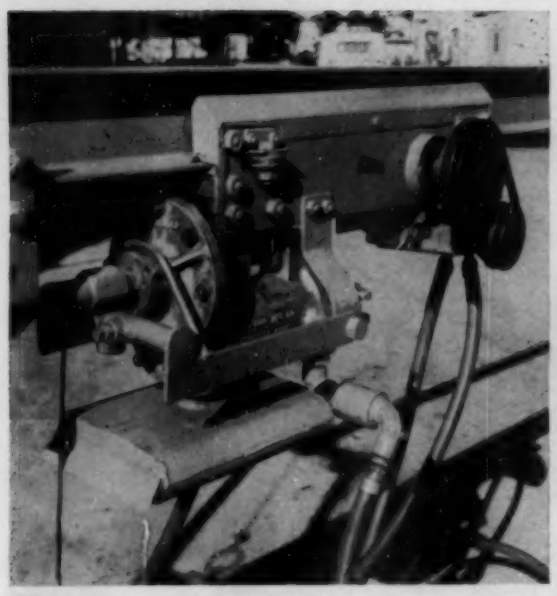
To clean the outsides of the bundles, Richfield engineers have developed a high-pressure water bundle washer. The bundle to be cleaned is placed on a pair of four wheel trucks that are mounted on rails for mobility. The trucks are adjustable and can be spaced to accommodate any length or size bundle. The loaded cars are moved back and forth by a pneumatic car puller through a 13 ft 8 in. long housing containing two high-pressure water nozzles on a swivel arm. High-pressure water from a 50-gpm, 2000-lb discharge pump is applied through these jets. The car puller and swivel nozzle are operated by one man standing at a window at the side of the housing. The bundle rests on rollers on the car trucks and is easily rotated for cleaning all the way around.

There are two of these washers standing side by side, so that while one bundle is being washed in one housing another is being set up on the second washer car for cleaning. The housings are mounted over a trench, and the wash water and debris flow into a separator where the water is recovered for re-use.

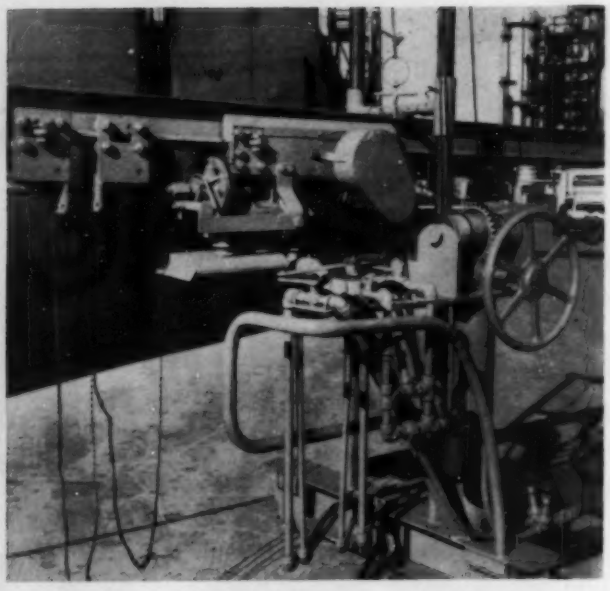
When the outsides of the bundles are covered with heavy, tarry residual oil or catalyst slurry, they are washed with hot gas-oil prior to high-pressure water cleaning. This is accomplished in four



Overall view of Richfield's internal bundle cleaner, showing pneumatic drive, lances and supporting structure.



Pneumatic drive unit, which pushes the lances through the tubes.



One-man operation is provided for by placing all controls at the left side of the head end of the machine.

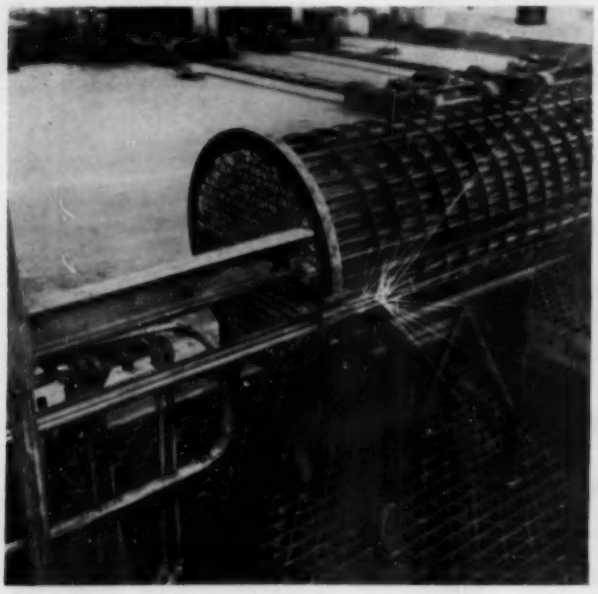
vertical tanks, 5 ft 8¼ in. by 18 ft 9 in. in size and partially buried underground. The bundles are placed in these tanks by the 10-ton overhead crane, and the gas-oil, heated by steam coils, is pumped between the tubes of the vertical bundle by jets located at various elevations around the shell of the tank.

In one of the tanks, two vertical pipes 180 deg apart, with slotted holes, are installed, and with present manifolding, it is possible to rotate the bundle and wash it with either oil, steam, water or air.

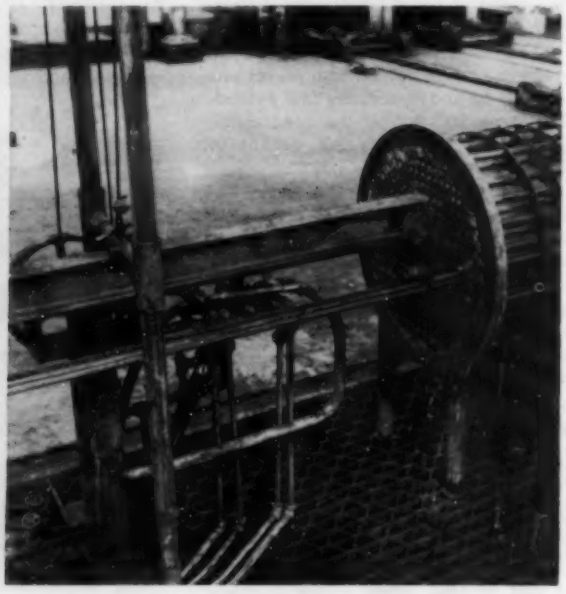
Tubeside of Bundles

In this same shop, personnel developed recently a machine for cleaning the inside of exchanger bundle tubes, requiring only one operator. Formerly, the tubes were cleaned by punching them with a hollow rod using water to clear the cleanings or drilling with a water drill turned by an air motor. Both the lance and drill required the efforts of two men to walk the drill back and forth pushing the cleaner through the complete length of the tube. Another man was required for inserting the rod in the next hole as each tube in the bundle was cleaned. This, at best, is a wet, arduous job, and the men must wear boots and rubber clothing for protection.

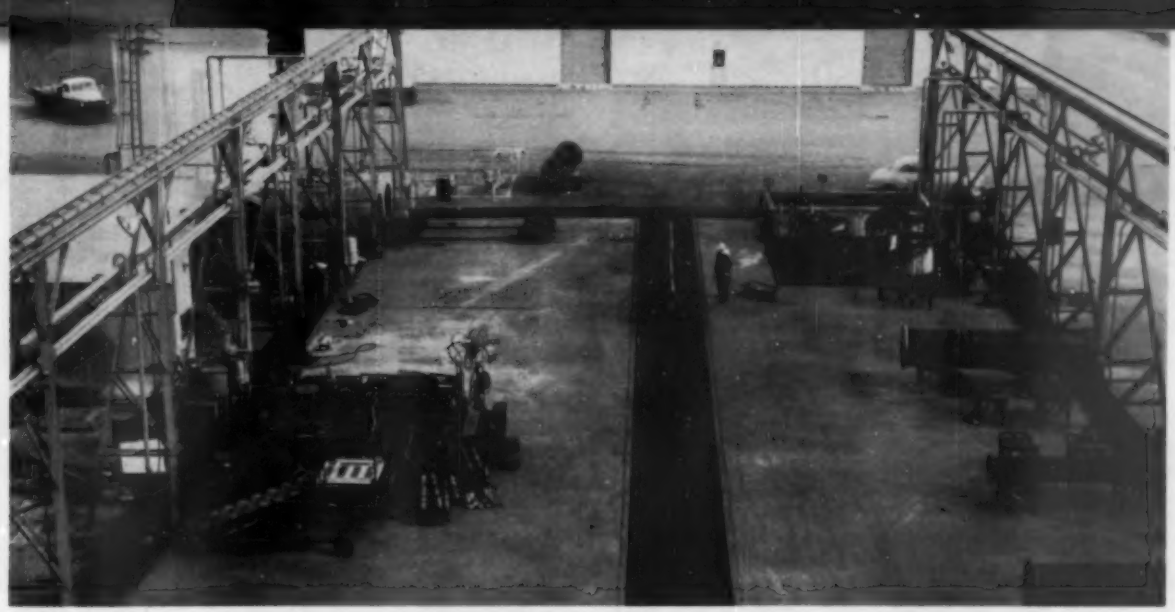
The new machine consists of a rotating rod or drill suspended and supported from a trolley beam, which in turn is supported from a structural frame allowing vertical positioning of trolley beam and lance. Lateral positioning is effected by movement of the complete carriage. The drill or lance is pushed through the tube by a pneumatic drive motor and friction clutch, which allows regulation of the proper



View showing the jet action of the three lances, by which three tubes may be cleaned simultaneously.



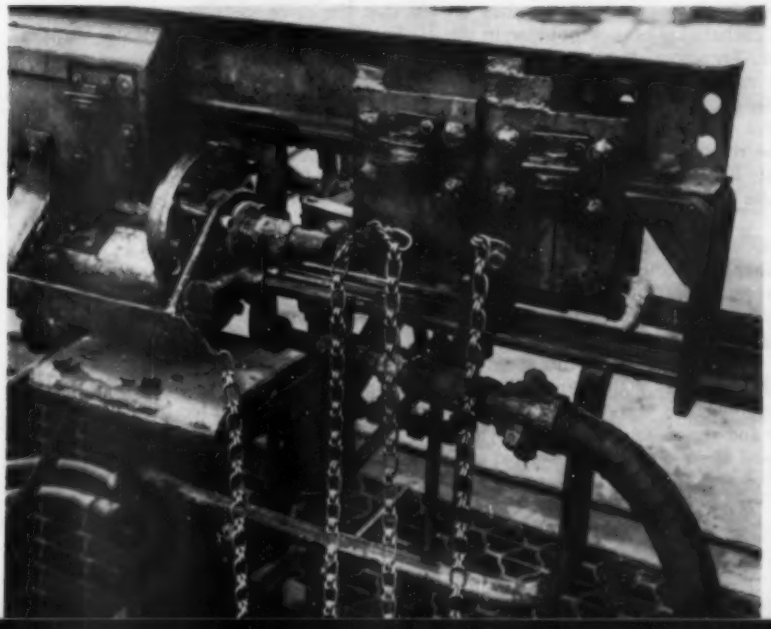
Lances entering tubes.



Cleaning areaway with traveling crane and auxiliary cleaning equipment.

Operator in position, and lances in fully inserted position.

Details of construction of pneumatic drive mechanism.



speed of travel according to the deposit or scale being cleaned.

Considerable success and speed of operation have been obtained by punching the tubes with 2000 lb of water pressure using triple lances for some deposits and using steam with a single lance on tubes plugged with catalyst or heavy bottoms.

Controls for the forward motion, as well as water or steam valves, drill rotation, and positioning are located at the left side of the head end of the machine for one-man operation. It is quite simple to use, requiring very little practice to master and develop speed of operation.

While the machine has proved itself to be an excellent tool for lancing and drilling operations, not nearly all of its possibilities have been explored fully.

★ ★ ★

Direct-Contact Gasoline Condenser

EXCLUSIVE

Methods for application of these condensers and design calculations are shown with typical examples

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THE principal of gas-liquid, direct-contact heat transfer has already been extensively employed in various industrial equipment such as cooling towers, air humidifiers and dehumidifiers, gas coolers, steam strippers and jet condensers. Application of direct-contact heat transfer to the solution of the vapor condensing problem has not yet, however, received wide attention. This is probably due to the fact that the advantage of direct-contact operation has not been fully recognized.

To our knowledge, heat transfer could be accomplished quite satisfactorily in condensing and cooling of petroleum vapors by direct contacting with water. A typical example is the condensation of gasoline vapor in a packed tower. This unique kind of condensing device has been adopted by the Kaohsiung Refinery to substitute conventional tube-and-shell of coil-in-box type condensers, and, after six years in service, these direct-contact condensers have proved themselves very practical and economical in solving the gasoline condensing problem, particularly that of sour gasoline.

Direct-Contact vs Indirect-Contact

One of the principal reasons for using tubes in the condenser is to prevent mutual contamination between the hot fluid and the cold fluid. But if the two fluids are immiscible with each other, as in the case of oil and water, there is no reason why an impervious surface is necessary. Using direct-contact apparatus, fouling and scale resistances are automatically eliminated by the absence of surface on which they can accumulate. And the fluids, after mixing and exchanging heat, may be readily separated in a settling tank. Therefore, the basically superior feature of direct-contact equipment over indirect equipment is that greater heat transfer coefficient can be resulted from greater intimacy of direct contact. This makes it possible for a large heat load to be removed in an apparatus of smaller volume. For example, a few feet of packing material may replace a large bundle of tubes or a big coil for the same heat load.

The direct-contact condenser is also lower in first cost, easier in maintenance, simpler in construction, and occupies smaller floor space than tubular condenser of equal duty. Since it is essentially a simple cylindrical vessel containing several feet of packings, construction material as well as erection cost and labor are considerably saved.

Direct-contact apparatus may be operated indefinitely with uniform thermal performance. The only maintenance work required is occasional cleaning of the inside and replenishing of broken packing materials after a long period of continuous service, usually two to three years, the pressure drop through the packing being an indication of whether the cleaning should be called for. Those laborious procedures of frequent cleaning of tube-scale for improving heat-transfer rate can be put aside forever.

But the most celebrated advantage of the direct-contact condenser is its immunity to corrosion. This is especially valuable in the condensing of corrosive distillates, such as gasoline from Middle East crude oil. Acidic constituents in sour gasoline tend to attack the tubes and in certain cases may cause perforation of the tube wall. This actually happened at a coil-in-box gasoline condenser after it had been put into operation for only six months when processing Kuwait crude oil. Using ceramic packing material, the troublesome work of periodic inspection and replacement for leak tubes are all eliminated. The cost of injecting alkali or other corrosion inhibitor is also greatly reduced.

Of course, there are also shortcomings, the most evident one being that the direct-contact condenser consumes more water than does the tubular condenser of equal heat duty. This is due to the fact that the available sensible heat gain of cooling water is limited by its final temperature, which is the same as the outlet temperature of the condensate. This sounds unfavorable. In certain places where power is cheap but material cost is high, use of more water instead of more costly materials is still justified, however, from the economical point of view.

Another reason that the direct-contact condenser is unpopular in the U. S. A. is perhaps the waste-water disposal problem. Since the mixing of oil and water provides a preliminary washing of the oil, slight contamination of the water is unavoidable. The waste-water may contain traces of dissolved substances of unseparated oil particles that may cause water pollution if discharged into small streams. Therefore, it is recommended that the water be either passed through an extra API-basin type separator, or be discharged into a large river or sea only.

Description of Apparatus

A direct-contact condenser usually consists of a vertical, cylindrical column, followed by a separator. The column is packed with a bed or two of packing materials such as Raschig rings or Berl saddles to extend the contact surface and time. Two columns operated in series or in parallel may be used if vapor temperature or flow rate is too high. The separator is a cylindrical vessel of either vertical or horizontal type. A typical apparatus, designed by the late Dr. K. Ping, former

manager of Kaohsiung Refinery, is shown in the accompanying sketch (Fig. 1). The condenser tower is packed with two beds of porcelain Raschig rings. The thickness of the upper bed is determined by calculation while the lower bed, with thickness that is only a fraction of the upper, is provided to prevent the vapor from flowing downward and to furnish additional cooling surface. The gasoline vapor line from fractionator overhead enters the condenser at a point between two beds of packing and is brought into contact counter-currently with cooling water, which is sprayed from a distributor at the top. For this reason, the apparatus is sometimes called "spray condenser." Since this name may lead to some misconception that it may resemble the spray tower or spray chamber used in air conditioning, which employs no contact surface and merely has a spray device, it is more rational to call this packed equipment the direct-contact condenser.

The condensed gasoline, along with water, flows downward to the bottom of the condenser and thence to a water separator, where the liquid separates into two layers, oil and water. The oil is forced continuously by the head established in the packed tower through an overflow weir to a receiver where reflux pump takes suction. The water is continuously discharged to the sewer.

The interfacial level controller automatically regulates the waste-water drain, and the condensate temperature controller controls the cooling-water supply line. The water inlet line is always overdesigned and the excess water compensated for by throttling when the tower is in operation. The temperature controller is optional because manual control is sufficient if the water pressure and the flow rate of oil vapor is steady enough.

A small after-cooler of the coil-in-box type is usually added to the system following the separator and preceeding the receiver. The purpose of this cooler is two-fold. First, it provides additional cooling surface in case the temperature of condensate is lower than the designed value needed. Corrosion is not encountered at the after cooler since the temperature of gasoline entering the after-cooler is already low enough. Second, it is served as a safety means in case the water pressure should suddenly drop owing to power failure. Should that happen, the water reserved in the cooler box may be used as temporary cooling medium. In normal operation, the packed tower should provide enough surface, and the after-cooler is bypassed unless further cooling is required. A more economical practice is to use the direct-contact condenser for condensing and cooling of gasoline to an optimum temperature and then to use the after-cooler for further cooling to desired temperature. In this way, the total cost of water and material can be reduced to a minimum.

Condensation of Vapor in a Packed Tower

Assume that the vapor from a fractionator overhead contains mainly gasoline vapor, some steam and a small amount of non-condensable gas. The condensation of such a mixture in a packed tower is rather complicated.

The ascending vapor, steam and gas are cooled and condensed, and the condensate descends along with the downcoming water while the non-condensable gas keeps going upward. Therefore, in the upper part of the tower, the gas and water flow countercurrently; but in the lower part of the tower, vapor meets condensate as well as water countercurrently while the condensate flows concurrently with respect to cooling water. This is illustrated in Fig. 2.

As the vapor ascends, it is cooled by both descending water and condensate. It begins to condense when the dew point of the mixture is reached. The vapor keeps ascending and condensing until it comes to a point where all condensable vapors are condensed, only the non-condensable gas remains and keeps ascending.

Meanwhile, as soon as condensate is formed, it flows downward. During the journey, it is cooled by the downcoming water and simultaneously heated by ascending vapor, but the net result is that the condensate is cooled from its bubble point to the desired outlet temperature while the water is heated to the same temperature as that of the condensate.

Since the vapor quality becomes less and less as it is go-

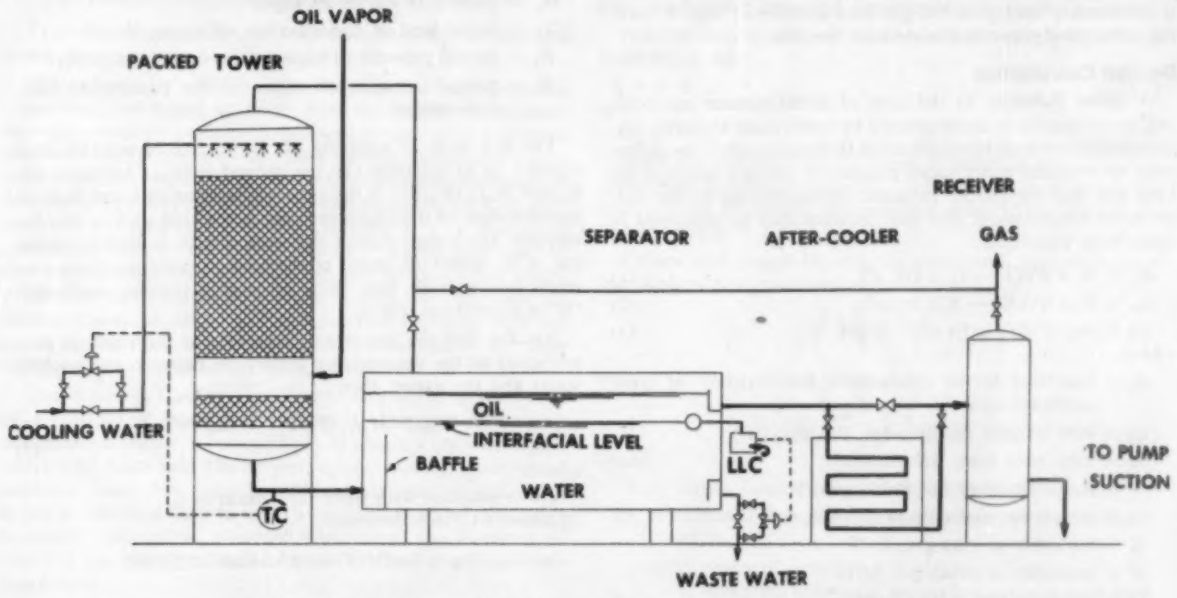

FIG. 1. Typical separator for use with a direct-contact condenser.

ing upward and is condensed, and the condensate quality becomes more and more as it is flowing downward, the vapor load and condensate load at various cross sections in the tower are not constant. The lower the cross section, the heavier the vapor and liquid load will be. Maximum vapor and liquid load occur at the bottom of the packing bed, i.e., at the vapor inlet. The NC-gas rate and the cooling water rate, however, remain constant throughout the tower.

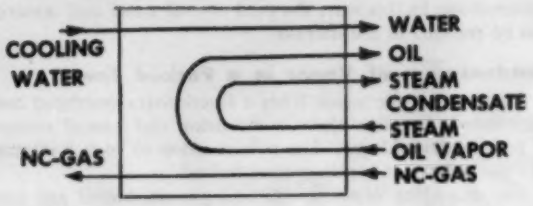

FIG. 2. Illustrative drawing of flows of materials in the condenser.

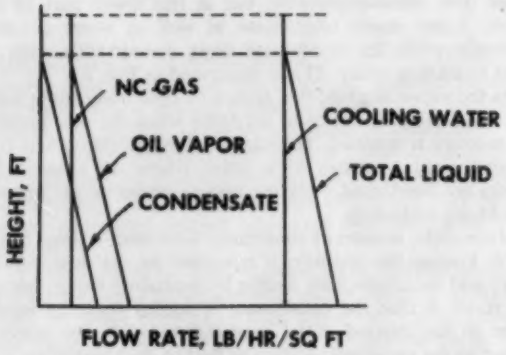

FIG. 3. Variation of the loads on the tower at different levels.

At the top of the packing bed, condensate load is zero, vapor load is equal to NC-gas load, and liquid load is equal to cooling water load. At the bottom of the tower, vapor load is condensate load plus NC-gas load and liquid load is cooling water load plus condensate load. See Fig. 3.

Design Calculation

A. **Heat Balance.** In the case of direct-contact gas cooling, heat transfer is accompanied by some mass transfer, i.e., dehumidification or humidification depending upon the difference between the water vapor pressure at the dew point of the inlet gas and the partial pressure corresponding to the outlet water temperature. The heat balance may be expressed in three basic equations:

$$dq_c = h_c\, a\, dV(T - t) = GC\, dT \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$$dq_d = K_x a\, dV(X' - X)\lambda = \lambda dL \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

$$dq = dq_c + dq_d = Ls\, dt = G\, dH \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where

q_c = heat transfer by convection, Btu/(hr)(ft²) of cross sectional area

q_d = heat transfer by diffusion, Btu/(hr) (ft²)

q = total heat load, Btu/(hr) (ft²)

T = temperature of hot fluid, (gas) F

t = temperature of cold fluid, (water) F

X = humidity of inlet gas, lb/lb

X' = humidity of outlet gas, lb/lb

G = gas mass rate, Lb/(hr) (ft²)

L = liquid mass rate, lb/(hr) (ft²)

C = humid heat of gas, Btu/(lb) (F)

λ = average latent heat of vaporization of cold fluid (water), Btu/lb

H = enthalpy of gas, Btu/lb

V = tower volume, in which heat transfer surface exists, ft³/ft³

a = surface area of packing, ft²/ft³

s = specific heat of liquid = 1 Btu/lb for water

h_c = overall coefficient of heat transfer, due to convection, Btu/(hr)(ft²)(F)

K_x = overall coefficient of mass transfer, lb/(hr)(ft²)(lb/lb)

These three equations are respectively the convection, diffusion and overall heat balance. Equations (1) and (2) can be related by the Lewis Number "Le,"[5] i.e., $h_c = (Le)\, K_x C$; and equation (3) is the sum of equations (1) and (2).

It should be noted that $a \times dV = dA$, where A is the heat transfer surface or the actually effective interfacial contact area between gas and liquid. Since A is impossible to determine, it is always interpreted as (a xV) times a correction factor, this factor being included in the transfer coefficient. The combined value of $h_c a$ or $K_x a$ is then regarded as an integrate overall capacity coefficient.

Now let us return to the case of direct-contact vapor condensate. In this case, things are somewhat different. First, the latent heat of condensation of vapor should be added to the total heat load. Second, if the concentration of noncondensable gas present in the vapor is relatively low and if all vapors are to be completely condensed, the amount of outlet gas will be negligible, which means that no water vapor would be carried away by the outlet gas due to diffusion. In other words, diffusion heat loss is Zero.

Therefore, equation (2) becomes zero, and equation (1) should be as follows:

$$dq = h_c a\, dV\,(T-t) + k_G a\, dV\, M_v \lambda_v (P_v - P_c) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

where

K_G = diffusion coefficient for vapor diffusing into condensate, gas film controlling, lb-moles/(hr)(ft²)(atm)

M_v = molecular weight of vapor

λ_v = latent heat of condensation of vapor, Btu/lb

P_v = partial pressure of vapor in gas body, atmosphere.

P_c = partial pressure of vapor at the condensate film, atmosphere.

The first term of equation (4) is the rate of sensible heat transfer as in equation (1); the second term of equation (4), $K_G a dV M_v \lambda_v (P_V - P_c)$, is the rate of liberation of latent heat of condensation of the vapor arriving at the cold surface of condensate. Since the value of the second term is hard to evaluate, it is, therefore, more convenient to combine these two terms into a single one, using an overall transfer coefficient "h" to cover both effects.

Assume that the rate of condensation of the vapor is proportional to the temperature difference between the cooling water and the vapor, then

$$K_G a dV M_v \lambda_v (P_V - P_c) = \varepsilon a dV\,(T-t) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

where

ε = a constant with same dimension as h_c

equation (4) then becomes:

$$dq = hadV(T - t) = Lsdt = \Sigma CdH \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

where

h = an overall transfer coefficient covering both cooling and condensation effects = $h_c + \varepsilon$

and

$$\Sigma G\, dH = G_v dH_v + G_c dH_c + G_g dH_g \quad . \quad . \quad . \quad . \quad . \quad (7)$$

in which

G_v = vapor (uncondensed) rate
G_c = condensate rate
G_g = non-condensable gas rate
H_v = enthalpy of uncondensed vapor
H_c = enthalpy of condensate
H_g = enthalpy of non-condensable gas

For the condensation of oil vapor-steam-NC gas mixture, the overall heat balance is rather simple, for only two ultimate conditions need to be considered, namely, inlet and outlet. The heat load is the difference between the total enthalpy of mixture at initial (inlet) temperature and that at final (outlet) temperature.

B. **Tower Capacity.** The minimum tower diameter required is determined by the maximum liquid and vapor load. Sherwood flooding correlation[1] is employed to solve this problem. The first step is to calculate the value of

$$\frac{L}{G}\left(\frac{\rho_G}{\rho_L}\right)^{1/2}$$

in which

L = liquid rate, lb/hr
G = vapor rate, lb/hr
ρ_G = vapor density, lb/ft³
ρ_L = liquid, density, lb/ft³

Then, from Sherwood flooding correlation curve, find the value of

$$\frac{u_o^2}{g}\frac{a}{F^3}\left(\frac{\rho_G}{\rho_L}\right)\mu^{0.2}$$

in which

u_o = superficial linear velocity of vapor at flooding point, ft/sec
g = gravitational constant, ft/sec²
F = fraction of free voids in packed volume or porosity of packing, no dimension
a = surface area of packing, ft²/ft³
μ = viscosity of liquid, centipoise

From the above value, find u_o, and from u_o the required tower diameter may be determined.

What should be noted is, as has been indicated before, that vapor load and liquid load vary with the height of the packing—the lower the position is, the heavier the liquid and vapor load will be. Therefore, the value of the liquid and vapor load should be taken at the point where severest conditions of flow exist. In the present case, this occurs at the packing support, where vapor feed enters. At this point, L = maximum condensate rate + water rate, and G = vapor feed rate. In this way, a safety factor is automatically involved, for actual value of L and G must be smaller. Additional allowance for diameter may be added to the calculated value, so that the tower can be operated within the recommended 50 per cent to 70 per cent of the actual flooding rate.

Theoretically, the tower could be constructed in the shape of a frustum of cone, with minimum diameter at top and maximum diameter at bottom so as to obtain a uniform vapor and liquid mass rate (lb/hr per square foot of tower cross sectional area), but, since to build a truncated conical vessel is less economical than to build a cylindrical vessel, the latter is usually adopted as standard equipment, the diameter of which is the calculated value based on maximum liquid and vapor load.

C. **Height of Packing.** The most important requirement for the accurate design of a packed tower is reliable capacity data of transfer coefficient. If no data pertaining to this specific system of oil vapor-water is available, we can, however, estimate the capacity coefficient from similar systems, using whatever correlating means we have on hand.

To calculate the required height of packing, we have to resort to diffusion theory, and the concept of "Height of a Transfer Unit" (HTU) and "Number of Transfer Units" (n_t), such as those used in humidification or absorption calculation, must be introduced.

Height of a Transfer Unit

Direct-contact heat transfer data can only be computed from mass transfer data by the following relation:

$$haV = L(Le)\, c\left(K_x a \frac{V}{L}\right) \quad . \quad . \quad . \quad . \quad (8)$$

Where

Le = Lewis No.
c = specific heat of gas, Btu/(lb) (F)

and $\left(K_x a \frac{V}{L}\right) = n_t$ or number of transfer units

The relationship between mass transfer coefficient and HTU is as follows:

$$H_{OL} = \frac{L}{K_L a \rho_L} \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

$$H_L = \frac{L}{k_L a \rho_L} \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

in which

H_{OL} = height of overall transfer unit, based on liquid-phase driving force, ft
H_L = height of individual liquid transfer unit, ft
$K_L a$ = overall transfer coefficient based on liquid-phase driving force, lb-moles/(hr) (ft²) (lb-moles/ft³).
$k_L a$ = liquid transfer coefficient lb-moles/(hr) (ft²) (lb-moles/ft³)
L = liquid mass rate, lb/(hr) (ft²)
ρ_L = density of liquid, lb/ft³

The best way to determine $K_L a$ is, of course, by experimental method. If experimental data are not available, however, established empirical formulae can be used.

Assume that system oil vapor-water is entirely liquid-film controlling, then,

$$k_L a = K_L a \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

and

$$H_L = H_{OL} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

Since the solubility of oil vapor in water is very low, this assumption is rather reasonable, and the validity of which has been proved by actual performance data of the direct-contact condenser.

Values of $k_L a$ and H_L may be calculated from Sherwood and Holloway's[2] correlations:

$$\frac{k_L a}{D_L} = \alpha\left(\frac{L}{\mu}\right)^{1-n}\left(\frac{\mu}{\rho_L D_L}\right)^{1-s} \quad . \quad . \quad . \quad (13)$$

and

$$H_L = \frac{1}{\alpha}\left(\frac{L}{\mu}\right)^{n}\left(\frac{\mu}{\rho_L D_L}\right)^{s} \quad . \quad . \quad . \quad . \quad (14)$$

where

L = liquid (water) mass rate, lb/(hr) (ft²).
D_L = diffusivity or diffusion coefficient, of gas in liquid, ft²/hr.
μ = viscosity of liquid, lb/(hr) (ft).
α and n are constants, depending upon type of packings chosen, for 1-in. Raschig rings, α = 110, n = 0.23.
s = 0.5 for general use.

The diffusivity D_L can be calculated from Wilke's relation: (3)

$$D_L = \frac{4.0 \times 10^{-7} T_L}{\mu(V_a^{1/3} - k_i)} \quad . \quad . \quad . \quad . \quad (15)$$

where

T_L = absolute temperature of liquid, R.
μ = viscosity of the solution, lb/(hr) (ft).
k_i = 2.0 for dilute solution in water.
V_a = molecular volume of solute (oil vapor), calculated from atomic volume.

Number of Transfer Units (n_t)

If the equilibrium curve and the operating line of the oil vapor-water system could be plotted, it would be quite simple to determine the number of transfer units required by means of graphical methods such as those used in absorber design. If equilibrium data for this specific system, however, are also not available, an approximate method may be used for this purpose.

It has been pointed out before that if non-condensable gas in the vapor mixture is very little and all condensable vapors are to be completely condensed, mass transfer is insignificant and diffusion heat load is negligible. Under this condition, the enthalpy of the hot fluid where there is no mass transfer is proportional to its temperature, and the potential for the heat transfer is the difference between the temperature of the hot fluid and temperature of water at any cross section in the tower. Therefore, a simplified method for calculating n_t thus becomes possible. From equation (6).

$$\int \frac{haadV}{L} = \int \frac{dt}{T - t}$$

or

$$ha\frac{V}{L} = \frac{\Delta t}{LMTD} \quad . \quad . \quad . \quad . \quad . \quad (16)$$

where

LMTD = long mean temperature difference between two ends of the packing, F.
Δt = temperature difference between inlet and outlet water, F.
L = water rate, lb/(hr)(ft²).
haV = overall capacity coefficient of heat transfer.

The number of transfer units then can be obtained by rearrangement of equation (6):

$$n_t = K_x a\frac{V}{L} = \frac{haV}{L(Le)c} \quad . \quad . \quad . \quad . \quad (17)$$

where

(Le) = Lewis number = $h/K_x c$
c = specific heat of vapor, Btu/(lb)(F)

The Lewis number for the system oil vapor-water may be calculated from the following equation:[5]

$$(Le) = \left(\frac{k}{\rho_G D_v c}\right)^{2/3} \quad . \quad . \quad . \quad . \quad . \quad (18)$$

where

k = thermal conductivity of vapor, Btu/(hr)(ft²)(F/ft)
ρ_G = vapor density, lb/ft³
c = specific heat of vapor, Btu/(lb)(F)
D_v = diffusivity of liquid vapor in gas (water vapor into oil vapor), ft²/hr

The diffusivity D_v of water through oil vapor can be calculated from the well known formula:

$$D_v = 0.0069 \frac{T_v^{3/2}}{P(V_A^{1/3} + V_B^{1/3})^2}\sqrt{\frac{1}{M_A} + \frac{1}{M_B}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (19)$$

where

D_v = Diffusivity, ft²/hr
T_v = absolute temperature of gas, R
P = total pressure of the system, atmosphere
M_A, M_B = molecular weight of the two gases, (water vapor and oil vapor)
V_A, V_B = molecular volume of the two gases

The required height of packing then equals to n_t times H_L.

D. Separator. The capacity of the separator is determined by the detention period or the time required for the oil globules in the water phase to rise from water layer to the oil layer. The time of residence of oil particles in the separator should always exceed the time of rise in order to insure complete separation.

The rate of rise can be obtained from Stoke's law:

$$u = \frac{1}{C_v}\frac{g D^2 (\rho_w - \rho_o)}{18} \quad . \quad . \quad . \quad . \quad (20)$$

where

C_v = deformation coefficient
u = rate of rise, cm/sec
g = gravitational constant, cm/sec²
ρ_w = water density, g/cc
ρ_o = oil density, g/cc
D = diameter of oil globule, cm
μ = absolute viscosity of water, poise

The correction factor $1/C_v$ may be omitted in the present case since it is greater than 1, so the error of the u calculated without applying $1/C_v$ will fall on the safe side.

The procedure of calculating separator dimension is illustrated in detail in the sample problem.

Sample Problem

The overhead of a distillation column in a topping unit contains 86,000 lb/hr of gasoline vapor (molecular weight 120), 300 lb/hr of non-condensable gas (mol. wt 50), and 5400 lb/hr of steam. On condensation the gasoline has a gravity of 60 deg API at 60 F. The vapor is at an initial temperature of 300 F and a pressure of 5.3 psig and is to be condensed and cooled to 120 F by water at 85 F in a direct-contact condenser packed with 1-in. Raschig rings. Calculate (A) cooling water required, (B) dimension of packed tower, (C) dimension of oil-water separator.

Solution:

(a) Heat load: assume the outlet NC-gas is at 110 F.

In: At 300 F.

Oil Vapor	86,000 × .355	= 30,500,000
Steam	5,400 × 1191.6	= 6,440,000
NC gas	300 × 343	= 102,800
Total enthalpy		= 37,042,800 Btu/hr

Out: At 120 F.

Oil	86,000 × 127	= 10,910,000
Steam Cond.	5,400 × 87.92	= 475,000
NC gas	300 × 246	= 73,800
Total enthalpy		= 11,458,800 Btu/hr

Total heat load =

$$37{,}042{,}800 - 11{,}458{,}800 = 25{,}584{,}000 \text{ Btu/hr}$$

$$\text{Cooling water required} = \frac{25{,}584{,}000}{120 - 85} = 732{,}000 \text{ lb/hr}$$

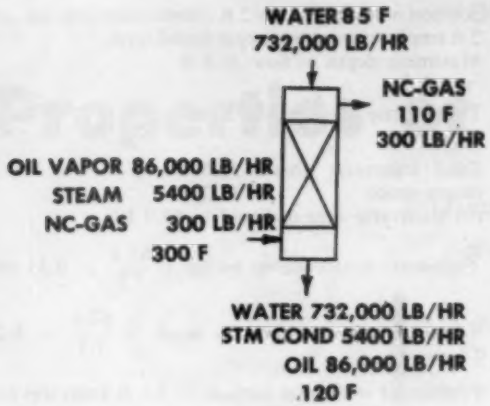

FIG. 4. Material balance in operation of the condenser.

(b) Capacity of Tower:

mols oil vapor	= 86,000/120 =	717
mols steam	= 5,400/18 =	300
mols NC gas	= 300/50 =	6
	Total mols	1023

$$\text{Total volume of vapor} = 1023 \times 379 \times \frac{760}{520} \times \frac{14.7}{20} = 417{,}000 \text{ ft}^3/\text{hr}$$

$$\text{density of vapor} = \frac{86{,}000 + 5{,}400 + 300}{417{,}000} = 0.22 \text{ lb/ft}^3$$

density of oil at 120 F = 44.4 lb/ft³
density of water at 120 F = 61.7 lb/ft³
apparent density of oil-water mixture =

$$\frac{86{,}000 + 5400 + 732{,}000}{\frac{86{,}000}{44.4} + \frac{732{,}000 + 5400}{61.7}} = 59.4 \text{ lb/ft}^3$$

$L = 86{,}000 + 5400 + 732{,}000 = 823{,}400$
$G = 86{,}000 + 5400 + 300 = 91{,}700$
$\rho_G = 0.22$
$\rho_L = 59.4$

$$\frac{L}{G}\left(\frac{\rho_G}{\rho_L}\right)^{1/2} = \frac{823{,}400}{91{,}700}\left(\frac{0.22}{59.4}\right)^{1/2} = 0.55$$

From Sherwood flooding correlation curve

$$\frac{u_o^2}{g}\frac{a}{F^3}\left(\frac{\rho_G}{\rho_L}\right)\mu^{0.2} = 0.043$$

a/F^3 for 1-in. Raschig ring = 155
μ = viscosity of liquid = 0.53 centipoise, $(0.53)^{0.2} = 0.88$
$g = 32.2$

$$u_o = \left(\frac{0.043 \times 32.2 \times 59.4}{0.88 \times 155 \times 0.22}\right)^{1/2} = (2.74)^{1/2} = 1.65 \text{ ft/sec}$$

$$\text{area required} = \frac{417{,}000}{1.65 \times 3600} = 70 \text{ ft}^2$$

$$\text{Diameter} = \left(\frac{70 \times 4}{\pi}\right)^{1/2} = 9.43 \text{ ft}$$

Use 9 ft 6 in. diameter tower

$$\text{Cross-sectional area} = \frac{(9.5)^2\pi}{4} = 70.7 \text{ ft}^2$$

$$\text{Maximum vapor mass rate} = \frac{91{,}700}{70.7} = 1300 \text{ lb/(hr)(ft}^2\text{)}$$

$$\text{Maximum liquid mass rate} = \frac{823{,}400}{70.7} = 11{,}660 \text{ lb/(hr)(ft}^2\text{)}$$

$$\text{Water mass rate} = \frac{732{,}000}{70.7} = 10{,}370 \text{ lb/(hr)(ft}^2\text{)}$$

(c) HTU
use equation (14)

$$H_L = \frac{1}{\alpha}\left(\frac{L}{\mu}\right)^n \left(\frac{\mu}{\rho_L D_L}\right)^s$$

$\alpha = 110$, $n = 0.23$, $s = 0.5$
$L = 10{,}370$
$\mu = 1.7$
$\rho_L = 62$

D_L is calculated by equation (15)

T_L = average temperature of liquid $= \frac{120 + 85}{2} =$ 102.5 F = 562.5 R
$\mu = 1.7$ lb/(hr)(ft) at 102.5 F
$k_1 = 2.0$ in water
V_s = molecular volume of oil vapor = $8 \times 14.8 + 18 \times 3.7 = 185$
(assume the oil are essentially C_8H_{18})

$$D_L = \frac{4.0 \times 10^{-7} T_L}{\mu (V_s^{1/3} - k_1)} = \frac{4.0 \times 10^{-7} \times 562.5}{1.7 \times (\sqrt[3]{185} - 2)} = 3.8 \times 10^{-5}$$

Substitute in equation (14)

$$H_L = \frac{1}{110}\left(\frac{10{,}370}{1.7}\right)^{0.23} \times \left(\frac{1.7}{62.0 \times 3.8 \times 10^{-5}}\right)^{0.5} = 5.75 \text{ ft}$$

and

$$k_L a = \frac{L}{H_L \rho_L} = \frac{10{,}370}{5.75 \times 62} = 29.1 \frac{\text{lb-moles}}{\text{ft}^3 \times \text{hr}} \Big/ \frac{\text{lb-moles}}{\text{ft}^3}$$

or

$$k_L a = 29.1 \times 62 = 1800 \frac{\text{lb-moles}}{\text{ft}^3 \times \text{hr}} \Big/ \frac{\text{lb-moles}}{\text{lb}}$$

(d) n_t

$$\text{LMTD} = \frac{(300 - 120) - (110 - 85)}{\ln \dfrac{(300 - 120)}{(110 - 85)}} = 78 \text{ F}$$

$$t = 120 - 85 = 35 \text{ F}$$

by equation (16)

$$\frac{ha\,V}{L} = \frac{\Delta t}{\text{LMTD}} = \frac{35}{78} = 0.45$$

$$ha\,V = 0.45 \times 10{,}370 = 4670$$

by equation (17)

$$n_t = \frac{ha\,V}{L(Le)\,c}$$

(Le) may be calculated from equation (18)

$$(Le) = \left(\frac{k}{\rho_G D_v c}\right)^{1/2}$$

$k = 0.0103$
$G = 0.22$
$c = 0.48$
D_v = may be calculated from equation (19)

$$D_v = 0.0069 \frac{T_v^{3/2}}{P(V_A^{1/3} + V_B^{1/3})^2} \sqrt{\frac{1}{M_A} + \frac{1}{M_B}}$$

$$T_v = 460 + \frac{300 + 110}{2}$$

665 R (average temperature of gas)

$P = 1.2$ atmosphere
$M_A = 18$, $M_B = 120$
$V_A = 14.8$, $V_B = 163$

$$D_v = 0.0069 \times (665)^{1.5} \times \left(\frac{1}{18} + \frac{1}{115}\right)^{0.5}$$
$$= 0.46 \text{ ft}^2/\text{hr}$$

$$1.2 \times [(14.8)^{0.333} + (185)^{0.333}]^2$$

$$(Le) = \left(\frac{0.0103}{0.22 \times 0.46 \times 0.48}\right)^{0.667} = 0.39$$

$$n_t = \frac{ha\ V}{L(Le)c} = \frac{0.45}{0.39 \times 0.48} = 2.4 \text{ units}$$

Required height of packing = 2.4 × 5.75 = 13.8 ft
Use 15 ft packing bed.

(e) Separator

Gasoline rate = 86,000 lb/hr
Water rate = 5400 + 732,000 = 737,400 lb/hr
Working temperature = 120 F
Gravity of oil = 60 deg API at 60 F or 67 deg API at 120 F specific gravity = 0.7128
Gravity of water at 120 F = 0.9885
Absolute viscosity of oil at 120 F = 0.42 centipoise
Absolute viscosity of water at 120 F = 0.5588 centipoise

Volume rate of oil $= \frac{86{,}000}{0.7128 \times 62.4} = 1930 \text{ ft}^3/\text{hr} =$ 0.536 ft³/sec

Volume rate of water $= \frac{737{,}400}{0.9885 \times 62.4} = 11{,}940 \text{ ft}^3/\text{hr}$ = 3.320 ft³/sec

Ratio volume water to volume oil $= \frac{3.32}{0.536} = 6.2$

Total volume rate = 0.536 + 3.32 = 3.856 ft³/sec = 231 ft³/min

Rate of rise of oil globule is calculated by Stoke's Law assume diameter of oil globule = 0.015 cm.

$$u = \frac{980 \times (0.015)^2 (0.9885 - 0.7128)}{18 \times 0.005588} = 0.605 \text{ cm/sec}$$
$$= 1.19 \text{ ft/min}$$

use a 10 ft dia. × 25 ft long horizontal tank, with the position of overflow weir 3 ft above center line, i.e., allow 2 ft empty space above upper liquid level.
Maximum depth of flow = 8 ft

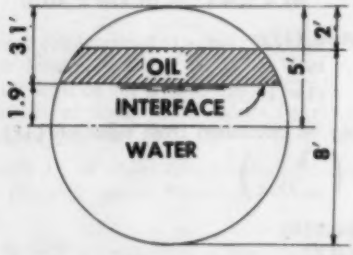

FIG. 5. Position of oil, water layers, and the interface in the separator.

Time of rise $= \frac{8}{1.19} = 6.72$ min

Total transverse area = 78.6 ft²
empty space = 11.2 ft²
net transverse area of liquid = 67.4 ft²

Transverse area covered by oil $= \frac{67.4}{7.2} = 9.35$ ft²

Transverse area covered by water $= \frac{67.4}{7.2} \times 6.2 =$ 58.05 ft²

Position of interfacial surface = 3.1 ft from top or 1.9 ft above centerline
Liquid volume in separator = 67.4 × 25 = 1680 ft³

Time of residence $= \frac{1680}{231} = 7.3$ min

Time of residence is well over the time of rise.

horizontal velocity of liquor flow $= \frac{231}{67.4} = 3.43$ ft/min

minimum length of separator required = 3.43 × 6.72 = 23 ft
10 ft by 25 ft tank is satisfactory.

Acknowledgment

The author wishes to express his appreciation to the management of Kaohsiung Refinery for their kind permission to publish this paper. The author also gratefully acknowledges many helpful comments and suggestions from M. C. Chang, J. S. Hu, S. F. Tung, H. C. Ting, T. C. Fei, S. C. Tsai, C. Chu and other staff members of Kaohsiung Refinery.

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Refinery By-Production of Sulfur Growing

Growth in sulfur production at petroleum refineries now is being forced by restrictive legislation on atmospheric pollution. Sulfur shortages in the past made by-product sulfur plants economically attractive in the early 1950's. Now, higher production from sulfur deposits is priced down in the face of increasing operating costs for the refinery producer.

Refinery sulfur plants serve to decrease overall contamination of the atmosphere by converting hydrogen sulfide vis an oxidation-reduction process to free sulfur. While production of refinery sulfur will be up about 12 per cent in 1956 over 1955 levels, considerations other than economics are the cause. Anticipated and/or enacted anti-pollution legislation coupled with greater production of refined products is spearheading current growth.

Seymour Schwartz, president of S. Schwartz & Associates, a New York consulting firm, believes by-product sulfur from refineries will be about 686,000 long tons in 1958, a growth of 71 per cent over a record production of 401,650 tons in 1955. He expects that refinery production will be about 10 per cent of the then expected total production, while it was less than 3 per cent in 1950.

Properties of Wyoming Crudes

Two general types are described — green, highly paraffinic, and black, high asphalt-content crudes

J. J. Pope
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Standard Oil Company (Indiana)

P 261.

WYOMING is the most important producer of crude oil in the Rocky Mountain area. Last year's production was about 275,000 bbl per day—55 per cent of the Rocky Mountain total. The Wyoming crudes are of many types, running the gamut in gravity, sulfur content, and other properties. This paper is primarily a discussion of where the crudes are found and how they compare in properties. Detailed refining characteristics are given for typical crudes, including data on Ultraforming, cat cracking, thermal cracking, and lube and asphalt production.

History and Geology

The geologists tells us that Wyoming was once part of a shelf area with fairly regular features. This area was covered by the seas of numerous geologic periods. In many cases, the eastern edges of these seas fell in Wyoming and relatively thin sedimentary layers were deposited there. Today, the surface terrain is quite rugged, the shelf area having been disturbed by the formation of mountain ranges. From a crude oil standpoint, the major interest is in the large structural basins separated from one another by these ranges. Along the rims of the basins, the sedimentary rocks have been considerably deformed, with many anticlines resulting. Most of the crude oil production comes from these rim areas, although more exploratory attention is being paid to the central portions of the basins.

Fig. 1 shows the principal basins and Fig. 2 lists the producing formations; together they give a three-dimensional picture of where the crude is found.

What was probably the first productive oil well in Wyoming was drilled in 1867, two years before Wyoming became a U. S. territory. It was not until 1908, however, that a really important oil find was made — Salt Creek field in the Powder River Basin. This Cretaceous discovery produced high-gravity, low-sulfur green crude. Salt Creek gave Wyoming its biggest oil boom and is still the state's largest field in terms of estimated ultimate recovery (in the neighborhood of 400,000,000 bbl).

Until about 1920, most discoveries were similar to Salt Creek, the crude being high in gravity, low in sulfur content, and from the Cretaceous. The majority of these fields were in the Powder River Basin, although there were a few similar-type discoveries in the Big Horn and Laramie basins.

During the 1920's, there were many discoveries in the Big Horn and Wind River basins. These produced a different type of crude oil — the heavy Wyoming black crude, found mainly in the Permian and Pennsylvanian. This crude is low in gravity, high in sulfur, and quite viscous. The gas produced along with the crude often contains high proportions of hydrogen sulfide. In many cases, such crude was

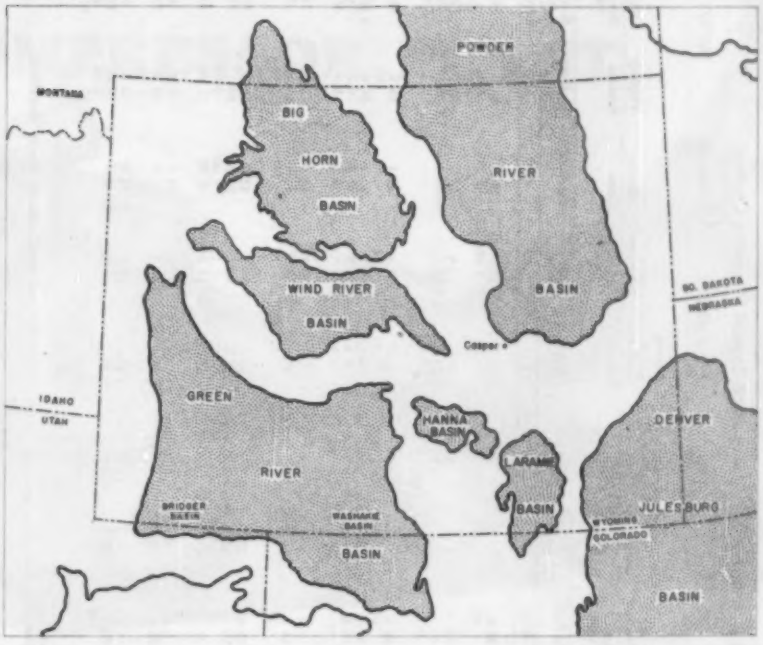

FIG. 1. Principal oil-producing basins of Wyoming.

ERA	PERIOD	PRODUCTIVE FORMATION OR EQUIVALENT
CENOZOIC	Quarternary Pliocene Miocene Obligocene Eocene Paleocene	White River Sand Wasatch Sand Ft. Union Sand
MESOZOIC	Upper Cretaceous	Lance Sand Mesaverde Sand Steele Shale Sussex Sand Shannon Sand 1st Frontier Sand 2nd Frontier Sand 3rd Frontier Sand Muddy Sand
	Lower Cretaceous	Dakota Sand Lakota Sand
	Jurassic	Morrison Sand Sundance Sand Nugget Sand
	Triassic	Curtis Sand
PALEOZOIC	Permian	Embar Limestone
	Pennsylvanian	Tensleep Sand Amsden Limestone/Sand
	Mississippian	Madison Limestone
	Devonian	
	Ordovician	Big Horn Dolomite
	Cambrian	Deadwood Sand
	Pre Cambrian	

FIG. 2. Producing formations found in Wyoming fields.

EXCLUSIVE

TABLE 1. Laboratory Analyses of Typical Wyoming Crudes.

Period	CRETACEOUS						JURASSIC			PERMIAN		PENNSYLVANIAN			MISSISSIPPIAN		ORDO-VICIAN
Producing formation	Mesaverde	Sussex	Shannon	1st, 2nd, 3rd Frontier; Lakota	3rd Frontier	Muddy	Dakota	Muddy, Dakota, Lakota, Sundance	Sundance	Embar	Tensleep	Tensleep	Amsden	Tensleep, Madison	Madison	Big Horn
Field	West Poison Spider	North Meadow Creek	Ash Creek	Salt Creek	Sand Creek	Clareton, S. W.	Sage Spring Creek	Laramie Basin Mix (1)	Stoumboat Butte	Gebo	Bonanza	Beaver Creek	Wertz	Elk Basin	Circle Ridge	Hamilton Dome
Basin	Wind River	Powder River	Powder River	Powder River	Big Horn	Powder River	Powder River	Laramie	Wind River	Big Horn	Big Horn	Wind River	Green River	Big Horn	Wind River	Big Horn
Producing depth, feet	9300	3000	4300	—	6700	6600	5500-7500	—	5100	4600	2930	10,400-10,900	6400	3000-5500	1600	3500
Crude																
Gravity, deg API	42.3	39.9	34.1	36.4	46.0	45.6	35.7	36.4	27.3	30.2	30.2	44.7	33.2	30.6	22.9	14.3
Sulfur, wt %	.09	.12	.13	.18	.04	.08	.20	.26	2.32	1.26	1.25	.56	1.29	1.57	2.53	3.20
Reid vapor pressure	—	8.0	2.0	—	—	11.1	6.1	—	—	6.0	—	7.9	—	—	—	1.7
Viscosity, SUS at 100 F	24.0	36.7	61.6	46.8	32	37.7	42.4	42.9	70.8	60.9	38.7	32	43.8	47.4	168	—
Pour point, deg. F	+35	LT-40	+15	+55	+10	—50	+40	+35	LT-35	—30	LT-40	—70	—40	—40	—60	+5
Carbon residue, wt %	0.3	1.1	3.0	1.5	0.3	—	3.3	2.0	—	—	3.1	0.4	2.8	3.8	6.4	11.5
Gasoline—400 F end point																
Yield, vol %	47.5	35.6	21.1	20.8	50.0	48.0	38.7	34.3	23.8	23.5	35.9	49.9	30.3	30.3	13.0	3.4
Sulfur, wt %	.02	.01	.03	.04	.04	.06	.02	.06	.14	.13	.07	.07	.04	.16	.09	.08
Research octane—3cc	82.0	69.8	87.0	80.9	83.5	84.7	84.3	82.3	80.9	80.3	81.9	82.9	87.9	85.9	84.3	45.6
Reid vapor pressure	7.7	7.7	3.0	3.3	—	10.7	6.8	5.9	3.4	6.7	4.9	7.3	1.1	4.8	0.8	6.3
Kerosine (2)																
Yield, vol %	12.1	14.5	13.1	11.7	9.8	10.1	—	9.7	10.4	10.0	13.0	14.2	11.9	11.8	6.9	8.7
Gravity, deg. API	42.0	43.0	46.0	40.4	43.2	44.3	—	41.8	39.7	41.3	41.1	43.1	42.9	38.5	42.7	30.0
Sulfur, wt %	.03	.01	.03	.06	.04	.01	—	.16	.72	.45	.44	.11	.27	.53	.44	.48
Virgin gas oil																
Yield, vol %	26.1	27.7	41.2	36.8	35.0	35.1	27.2	32.0	38.6	32.3	40.0	40.9	46.6	39.0	42.7	24.9
Gravity, deg. API	35.4	35.5	27.1	24.9	36.1	36.6	34.1	34.6	30.0	33.2	30.1	34.1	31.1	35.5	33.2	27.0
Sulfur, wt %	.06	.06	.07	.09	.04	.09	.24	.09	1.16	1.30	2.06	.75	1.36	1.55	1.56	2.32
Watson Factor	11.85	11.88	12.04	11.58	11.87	11.94	11.73	11.79	11.84	11.97	11.40	11.74	11.60	11.44	11.68	11.40
Heavy distillate																
Yield, vol %	9.2	13.8	13.3	18.2	5.1	8.6	8.3	19.7	17.4	25.6	5.2	4.9	12.5	14.4	12.9	14.0
Gravity, deg. API	25.9	24.5	28.1	27.0	28.1	29.1	27.1	25.0	26.0	22.0	19.6	22.6	20.8	19.1	18.5	16.9
Resid. above heavy distillate																
Yield, vol %	0.3	10.6	23.8	13.3	5.1	8.6	22.1	12.6	19.5	14.9	15.6	3.1	11.5	17.1	27.9	47.3
Gravity, deg. API	17.1	14.1	17.1	15.9	20.0	22.1	15.1	13.3	3.9	4.7	15.0	10.7	9.0	8.9	6.3	6.3
Sulfur, wt %	.36	.49	.30	.51	.16	.18	.43	.79	—	—	4.16	2.34	2.66	3.56	4.22	4.30
Viscosity, SSF at 210 F	50	88	73	78	—	23	36	235	—	80	—	67	102	374	1160	2100
Carbon residue, wt %	7.6	13.5	13.0	10.8	—	—	11.4	12.1	—	13.1	—	—	21.1	19.4	20.7	—

(1) A mixture of crudes from Quealy, Cooper Cove, Sutton Creek, Rock Creek, and Medicine Bow Fields.
(2) Blend of last gasoline cut and first gas oil cut. Non-overlapping products are: Gasoline, gas oil, heavy distillate, and resid. above heavy distillate.
LT = Less than.

found by deeper drilling in fields that had previously produced low-sulfur crude from the Cretaceous. Because of difficulty in handling, corrosiveness, and undesirable refining characteristics, the demand for this black crude was limited. Many fields were shut in for lack of a market.

The depression years hit Wyoming exploration severely, and there were not many significant discoveries during the early 1930's. The latter part of this decade and the 1940's saw numerous additional black oil discoveries — mainly in the Big Horn and Wind River basins.

More recently, the Powder River Basin has regained the exploration spotlight. There have been many sweet crude discoveries there, including some Pre-Cretaceous. On the west flank of the basin, the Sussex area is important, while on the east, Weston County stands out with its Newcastle (Muddy) wells.

Today the Green River Basin is of importance primarily for its gas potential. There are a few small oil fields within the basin, and the important Lost Soldier-Wertz area is located on the basin's northeast boundary.

Most of the Denver-Julesburg Basin falls outside of Wyoming. The small Wyoming portion, however, will see more exploration work because of Muddy discoveries made there last year.

Crude Properties

Analyses made in Standard's laboratories on typical Wyoming crudes are summarized in Table 1. Oils from a wide range of producing horizons are shown. The fields are arranged according to horizon, with the youngest on the left. The Cretaceous crudes are high-gravity, low-sulfur, and paraffinic (as indicated by Watson characterization factors of 11.80 and higher). In many ways, the Cretaceous crudes are similar to Mid-Continent crude. They have a high yield of straight-run gasoline and produce excellent quality kerosine. Many of them are suitable for lube oil manufacture.

Crudes from the older formations (Permian, Pennsylvanian, Mississippian, Ordovician) are, for the most part, lower in gravity than the Cretaceous crudes. As shown in Table 1, the gravity may go down to 14 deg API, corresponding to a resid content of almost 50 per cent. Oils from these older horizons nearly always show a sulfur content above 1 per cent, and the majority fall in the 2 to 4 per cent range. These black crudes are usually naphthenic (Watson factors in the 11.40 to 11.65 range). High sulfur contents of gasoline and kerosine are important disabilities. Some black crudes

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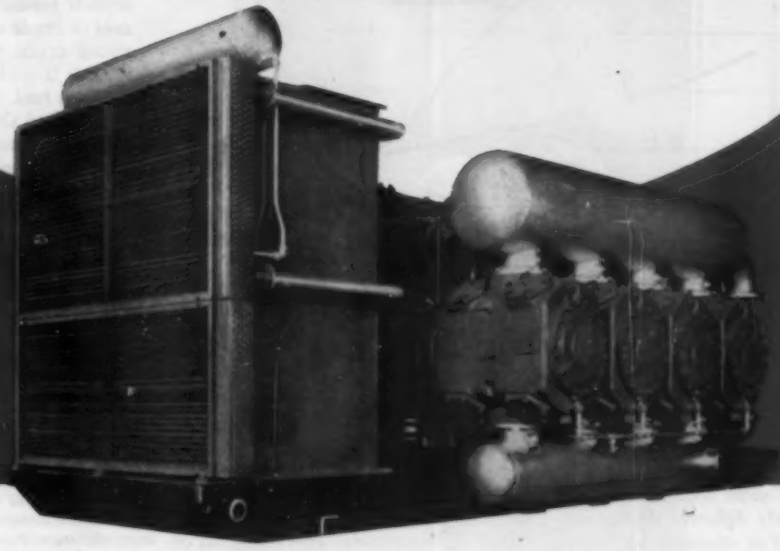

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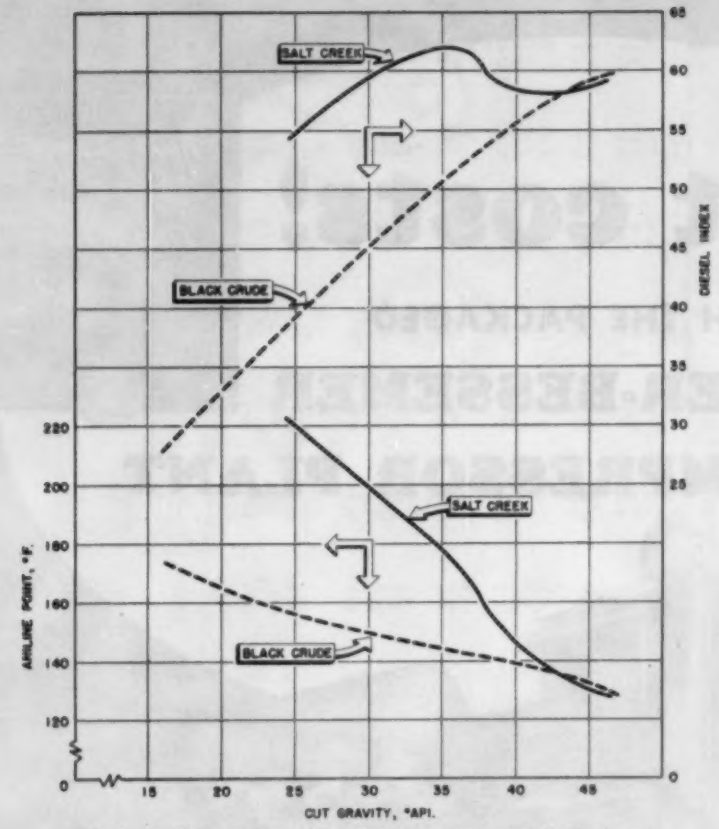

FIG. 3. Aniline point and diesel index of cuts from Salt Creek and from black crudes.

are used for asphalt manufacture.

Table 1 also shows the producing depth for each field listed. The depths of the different formations vary widely. In addition, the same formation may be found at vastly different depths in different areas. For example, at Bonanza field in the Big Horn Basin, the Tensleep is found at 2600 ft; while at Beaver Creek field in the Wind River Basin, it is found between 10,000 and 11,000 ft. These two Tensleep crudes are as different in properties as they are in depth. The Bonanza crude is 36.2 deg API with a sulfur content of 1.86 per cent, while Beaver Creek-Tensleep shows a gravity of 44.7 deg and a sulfur of 0.55 per cent. This variation of gravity and sulfur with depth often holds true when comparing crudes *from the same horizon*. In general, the deeper the crude is found, the higher

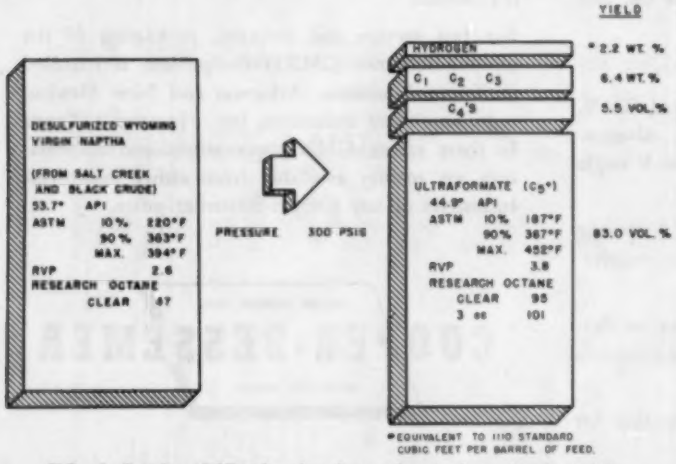

FIG. 4. Results of Ultraforming (cat reforming) a mixed naphtha from Salt Creek and black crudes.

in gravity and lower in sulfur content it tends to be.

Refining and Products

Before considering the refining characteristics of some typical Wyoming crudes, it is of interest to summarize the refining situation within the state. Wyoming has thirteen operating refineries that process about 90,000 bbl per day— one third of the state's crude oil production. The major refining units in operation as a per cent of crude running capacity are:

	Per cent
Thermal cracking	12.6
Cat cracking	29.8
Thermal reforming	3.2
Cat reforming	4.3
Coking	8.0

The above is based on charge capacity for the various processes. Lube and asphalt *production* represents 11.1 per cent of crude running capacity. The reduced crude not used for coking or asphalt is sold as fuel — most of it as railroad fuel.

Standard Oil Company's Casper refinery processes light Salt Creek crude as one stream and a mixture of the heavy black crudes as another. Table 1 includes analytical data on Salt Creek as well as on some of the black crudes that are in the composite black stream. Fig. 3 compares the aniline point and diesel index of the two streams. The higher diesel indexes for Salt Creek show it to be much more paraffinic than the black crude.

The Authors

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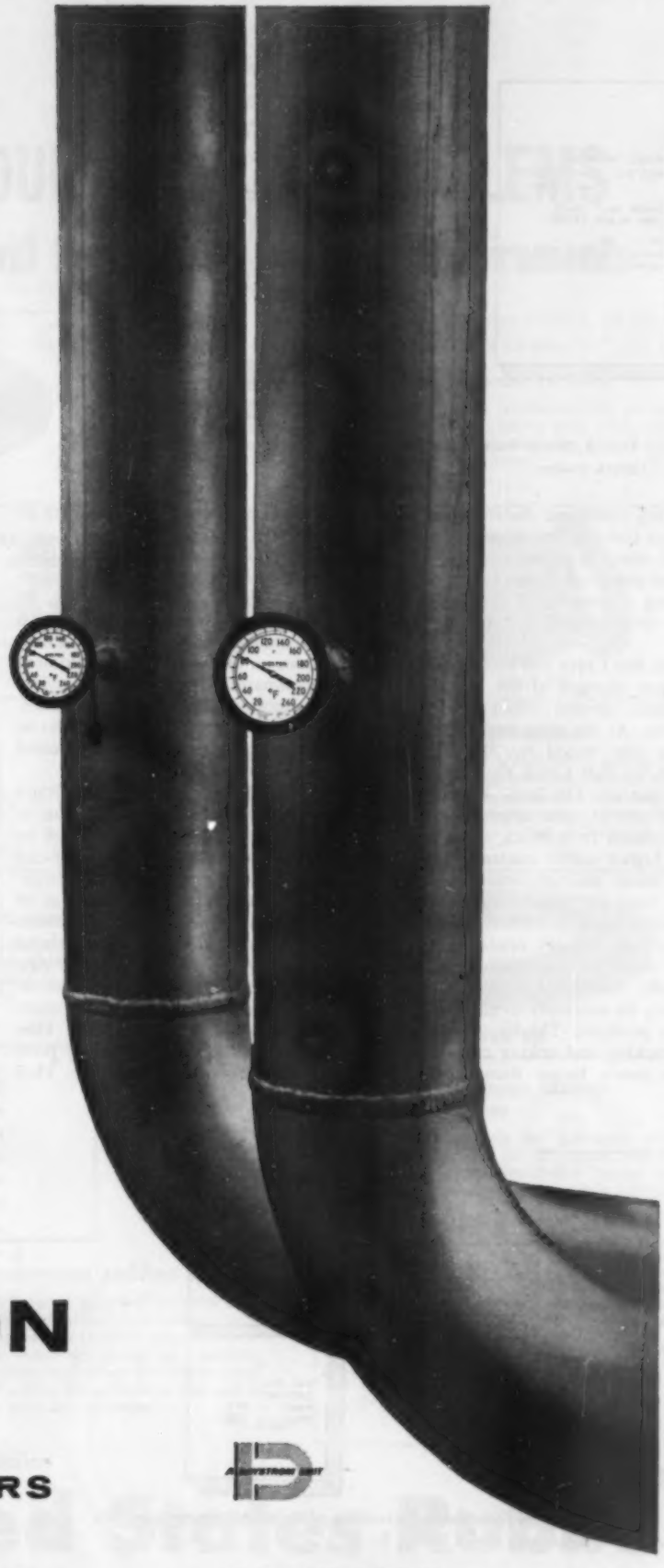
R. R. Wilber is assistant supervisor of the plans division, crude oil coordination department, Standard Oil Company (Indiana). He received a BS in chemical engineering from the University of Illinois and served in the Navy during World War II as an engineering officer on destroyers. In 1946, Wilber joined Standard in the technical service department at the Whiting, Indiana, refinery. He was transferred to the crude oil coordination department in 1948.

Fig. 4 shows Ultraforming pilot plant data on a heavy naphtha obtained from both Salt Creek and black crudes. The Ultraformate has a research octane number of 95 — an increase of 48 units over the straight-run charge. The yield is 83 per cent, and the hydrogen production 1110 cu ft per barrel of feed.

In Fig. 5, plant yields are shown for cat cracking a mixed gas oil obtained from both Salt Creek and black crude. The feed is about three-fourths virgin and one-fourth cokestill gas oil. At the



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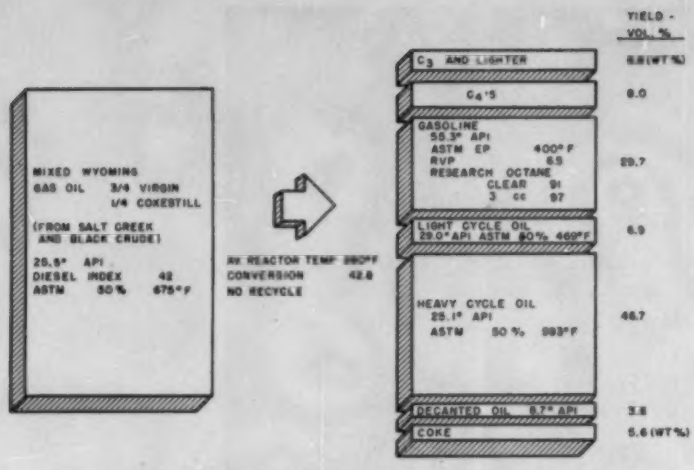

FIG. 5. Yields from cat cracking a mixed oil from Salt Creek and black crudes.

operating conditions shown, a yield of 29.7 per cent gasoline is obtained with a clear research octane of 91. In Fig. 6, plant yields are shown for thermally cracking a mixture of the light and heavy-cycle oil obtained in cat cracking.

If the Salt Creek and black crude gas oils were charged to the cat cracker separately, several differences would show up. At the same conversion, the charge rate would be 50 per cent greater for Salt Creek than for black crude gas oil. The latter has a much higher rate of coke deposition. Also, the products from black crude would show higher sulfur contents. In general, these characteristics of black crude limit its substitution for light, low-sulfur crude in refinery processing. First of all, refinery operating equipment must be corrosion protected. Secondly, additional processing facilities may be necessary to eliminate sulfur in products. Thirdly, a refinery's cat cracking and coking capacity has to be much larger than would be needed to process an equal amount of light crude.

Heavy distillate fractions from Salt Creek crude are used for the manufacture of lubricating oils and wax. In Table 2, Salt Creek is compared with Mid-Continent crude. The Salt Creek contains more wax than Mid-Continent and compares favorably with it in yield and viscosity index of lube distillates. In this respect, Salt Creek is similar to a number of other green crudes found in the Powder River Basin.

Several different types of asphalt are produced from the black oil run at Casper. Paving asphalt is produced by vacuum distillation of the reduced crude until it has the desired penetration characteristics. The variation of penetration with gravity of reduced crude is shown in Fig. 7. Table 3 shows inspections on a popular grade of paving asphalt — 100 to 120 penetration.

Korites are another type of asphalt manufactured from black crude. They are products of high softening point and relatively soft consistency. They find use as roof coatings, cements, binders, and electrical insulators. One grade of Korite asphalt is described in Table 3. It is produced from a 6.3 deg API reduced crude that is blown with heated air for approximately 30 hr to attain the proper degree of oxidation.

In addition to being refined in the Rocky Mountain area, as described above, Wyoming crudes move eastward in substantial quantity. Last year, this movement to Midwest refineries totaled about 130,000 bbl per day. The large diameter pipe line from Ft. Laramie, Wyoming, to Freeman, Missouri, completed late in 1954 by Service Pipe Line Company provides additional capacity for this movement. By means of this line and the Platte Pipe Line, Wyoming crudes are today finding large outlets in the Midwest market. Their refining characteristics are thus becoming of greater importance to the Midwest refiner. ★ ★ ★

TABLE 2. Comparison of Salt Creek and Mid-Continent lubes.

	Salt Creek	Mid-Continent
Crude		
Gravity, deg. API	30.4	37.4
Sulfur, wt %	.11	.39
Watson factor of virgin gas oil	11.85	11.83
Paraffin distillate		
Yield, vol %	35.4	26.9
Viscosity, SUS at 100 F	77.6	77.2
Estimated yield of 120.5 F melting point wax, wt % on distillate	8.0	2.6
SAE 20 distillate		
Yield, vol %	9.6	6.9
Viscosity index*	84	84
SAE 40 distillate		
Yield, vol %	9.4	3.
Viscosity index*	87	44

* After dewaxing distillate to pour point of 0 F.

TABLE 3. Inspection data on paving asphalt, from Wyoming black crudes, of 100 to 120 penetration.

	Paving asphalt	Korite asphalt
Gravity, deg. API	5.8	—
Softening point, deg F	107	180
Penetration at 32 F	22	15
Penetration at 77 F	114	30
Penetration at 115 F	300+	54
Ductility at 77 F	100+	—
Flash point (Cleveland Open Cup), deg. F	565	470
Oliensis spot test	Negative	—

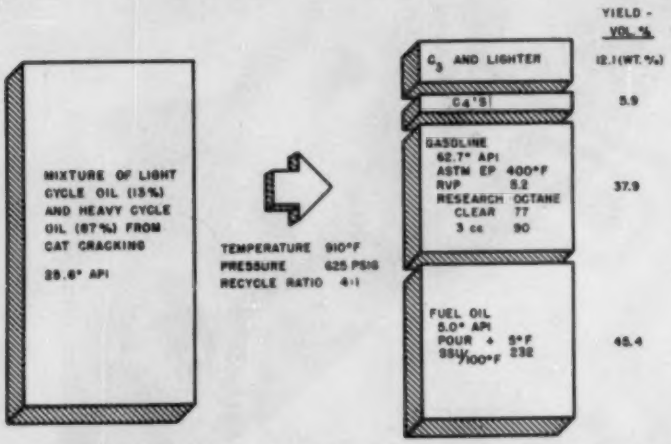

FIG. 6. Yields from thermal cracking of light and heavy-cycle oils from cat cracking as shown in Fig. 5.

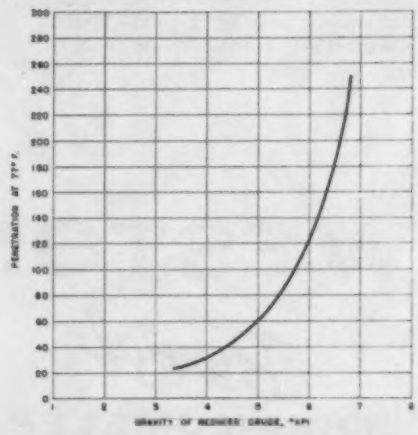

FIG. 7. Variation of asphalt penetration data with gravity of the reduced crude.

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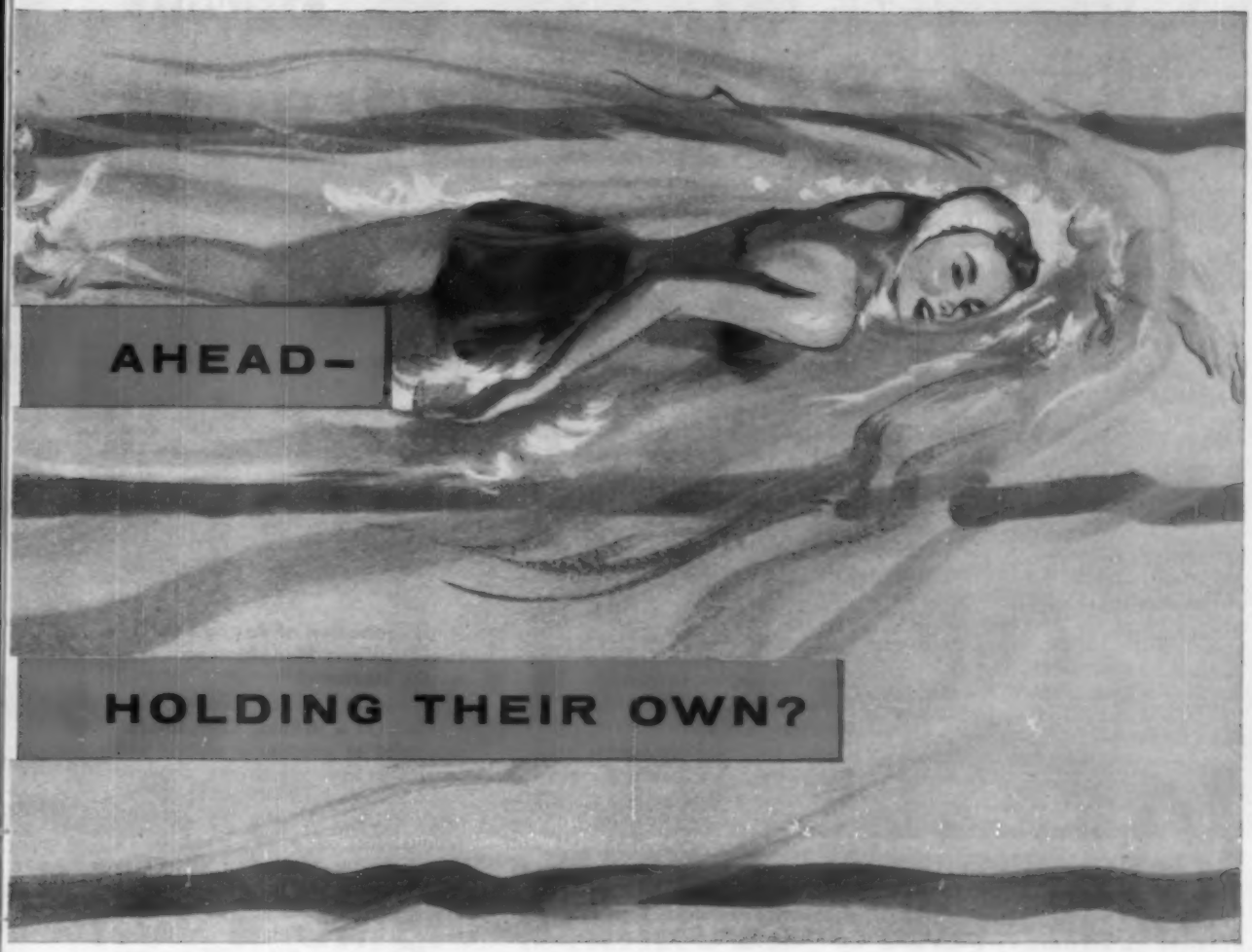

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OF special interest to refiners, in the program of the Petroleum Division, American Chemical Society, held in Atlantic City the week of September 17, was the symposium on the uses of refinery hydrogen. Originally developed by German scientists near the turn of the century, commercial units for upgrading low-quality residuums appeared in the U. S. in 1930. Heralded by the predicted rapid depletion of our crude oil reserves, incentive for the high pressure hydrogenation process disappeared with the discovery of large reserves in East Texas in the fall of 1930. Then, in 1950, cheap by-product hydrogen became available from catalytic reformers. This, coupled with development of the cobalt molybdate catalysts that permitted "low-pressure" hydrogenation brought the process to the fore.

Installed refinery capacity of hydrogenation processes was only 15,000 BPD in 1950. It is now nearly 350,000 BPD and growing rapidly. With the growth of catalytic reforming continuing strong, there is little danger that hydrogen supply will outstrip demand. About 1,000,000 bbl of naphtha are processed in catalytic reformers every day; indications are that this capacity will be doubled by 1965.

Hydrogenation processes are used to upgrade a wide variety of products and intermediates. They are used to remove sulfur from catalytic reformer feeds, remove sulfur and improve other important qualities in gas oils charged to catalytic crackers, and in some cases desulfurize the whole crude. Under a variety of trade names such as Hydrofining, Unifining, Autofining, etc., hydrogenation of cracked and virgin naphthas upgrades them for blending into motor gasolines. Under controlled conditions, unstable, gum-forming compounds are removed.

Octane Loss Reduced by Selective Hydrogenation

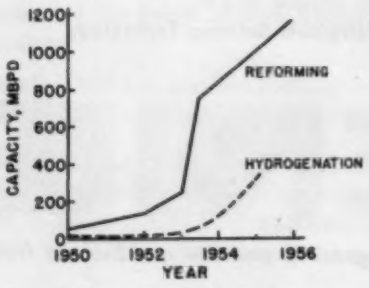
When hydrofining cracked gasolines, olefins are saturated to the detriment of research octane number. A paper presented by representatives from Houdry Process Corporation described how cracked gasolines of relatively high sulfur content can be selectively hydrodesulfurized to satisfactory sulfur levels without loss of octane number. The greatest portion of the sulfur is concentrated in the high boiling, olefin-poor fractions of cracked stocks. Feed is prefractionated, and only the heavy material hydrodesulfurized over Co-Mo catalyst at 300 psig. It is important that hydrogenation of the C_8 and C_9 aromatic hydrocarbons be avoided.

Desulfurization Increases Reforming Catalyst Life, Decreases H_2S Corrosion

Shell Oil Company experts reported that catalyst activity reduction rate can be nearly 10 times greater when processing a naphtha containing 0.17 per cent sulfur as when feeding stock with only 0.10 per cent sulfur. Higher yields, less corrosion when feeding desulfurized stocks can justify pretreating with hydrogen for almost all reformer feed stocks.

Benefits From Hydrotreating of Cat Cracker Feeds

In addition to eliminating need for resulfurization of products, hydrotreating of gas oil feed to catalytic crackers provides several other benefits, according to Phillips Petroleum Company. These often overshadow benefits of improved product quality; carbon production is reduced, and throughputs in units formerly limited by carbon burning capacity can be increased by as much as 20 to 30 per cent; higher C_5 430F gasoline production results from better yield distribution and higher feed rates; higher catalyst activity and life from reduction of metal contaminants in the feed; and reduced hydrogen sulfide in the unit, which in turn decreases corrosion rates and eases the recovery of light gases for alkylation or polymerization plant feeds.



Rapid Growth of Petroleum Catalytic Reforming and Hydrogenation Capacities.

Hydrogenation of Asphalt for Fuel Products Manufacture on the Horizon?

A team of research chemists from Humble Oil & Refining Company has succeeded in combining asphalt and by-product hydrogen to make valuable stocks such as gasoline, heating oil, gas oil satisfactory for cat cracking, and residual fuel oil, it was reported. To date, attempts to convert asphalt to fuel products has resulted in high losses, along with high gas and coke make. It is claimed that the new hydrogenation process has a 105 per cent yield volumetric of fuel products.

Using a feed stock consisting of 13 per cent bottoms from mixed South Central Texas crudes, yields of as high as 20 per cent gasoline and heating oil, 40 per cent cat cracker feed, and 45 per cent residual fuel oil were observed. The hydrogenation is carried out at these general conditions: 725-825F temperature, 400 to 800 psig total pressure, and space velocities ranging from 0.5 to 2.0 volumes of feed per volume of catalyst. The cobalt-molybdate-on-alumina catalyst may be used, under selected conditions, for 500 hours; it is regenerated by burning off accumulated carbon deposits. Hydrogen consumption is anywhere from 300 to 1000 SCF per barrel, with recycle rates up to 3000 SCF per barrel.

Overall profits of $50 to $80 per 100 bbl of feed are predicted by the Humble research group.

Good Future Predicted for Lube Additives

Dr. Robert S. Aries, of the firm bearing his name, predicted during the

Reflux condensers for soap neutralization, made from ⅛"-thick type 304 Stainless.

Not a Single Stainless Steel failure

in equipment for handling finished detergents

Synthetic detergent tanks (Stainless) have been in service for four years and are still as good as new. Previous coated tanks lasted 18-24 months.

The Atlantic Refining Company's Philadelphia refinery produces detergents as one of the derivatives.

Product contamination was the big problem. They tried sprayed-on plastic and phenolic coatings, but they all failed. Since they installed Stainless Steel, there has not been a single failure in the finished product handling equipment. There has been no corrosion problem. No contamination.

Nothing can equal Stainless Steel in its combination of properties: corrosion resistance, surface smoothness and denseness, strength and hardness, easy fabrication. Think of Stainless when you plan. Think of *USS* Stainless when you buy.

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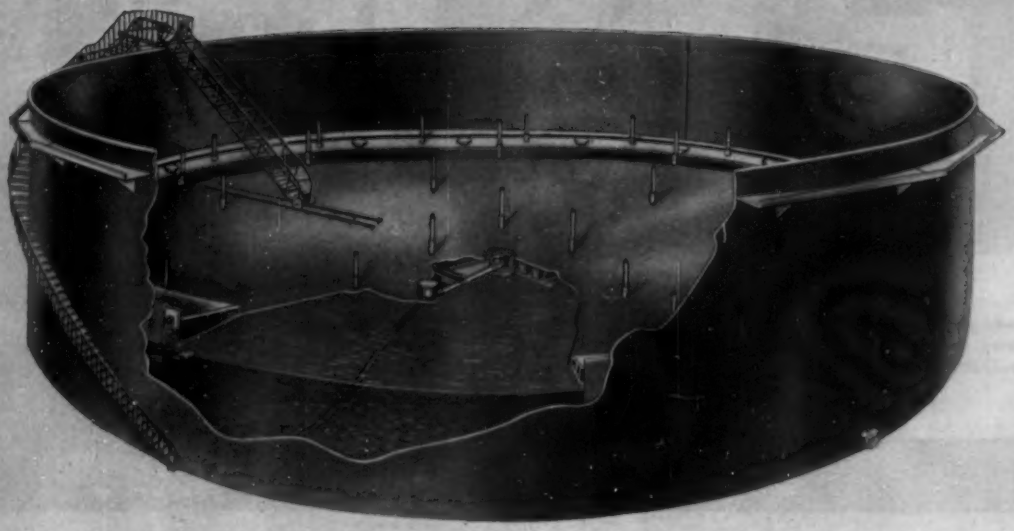
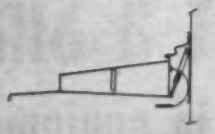


STABLE . . . because, ship-like, the center of buoyancy is below the center of gravity.

CORROSION-RESISTANT . . . because the liquid in storage is in full contact with the deck.

SELF-DRAINING . . . rainfall flows to the Graver sump at the center low point of the roof.



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. . . FOR A NEW, LOW-COST FLOATING ROOF TANK WITH UNDER-DECK CENTER WEIGHT

Here is another outstanding Graver first in single-deck floating roof tanks. We've cleared the deck for easy snow removal and positive drainage by putting the center weight *below* the deck. This effects additional economies in construction without sacrificing the long-established advantages of Graver's patented single-deck floating roof principle and characteristic Graver quality. This new Graver floating roof tank (both pontoon and pan type) has been thoroughly proved by installations across the nation. May we give you complete details?

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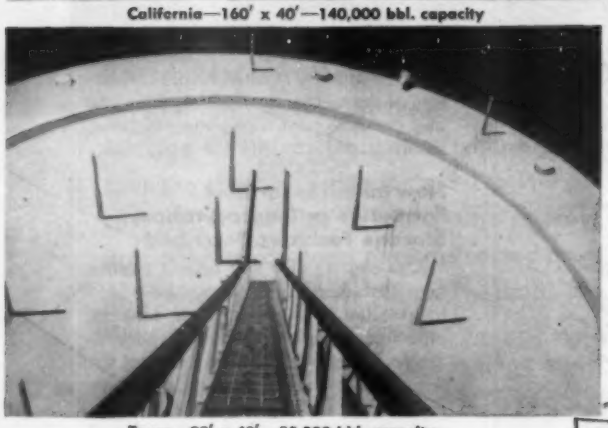
New Jersey—140′ x 40′—110,000 bbl. capacity

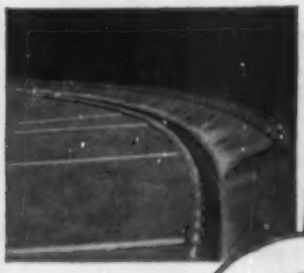
California—160′ x 40′—140,000 bbl. capacity



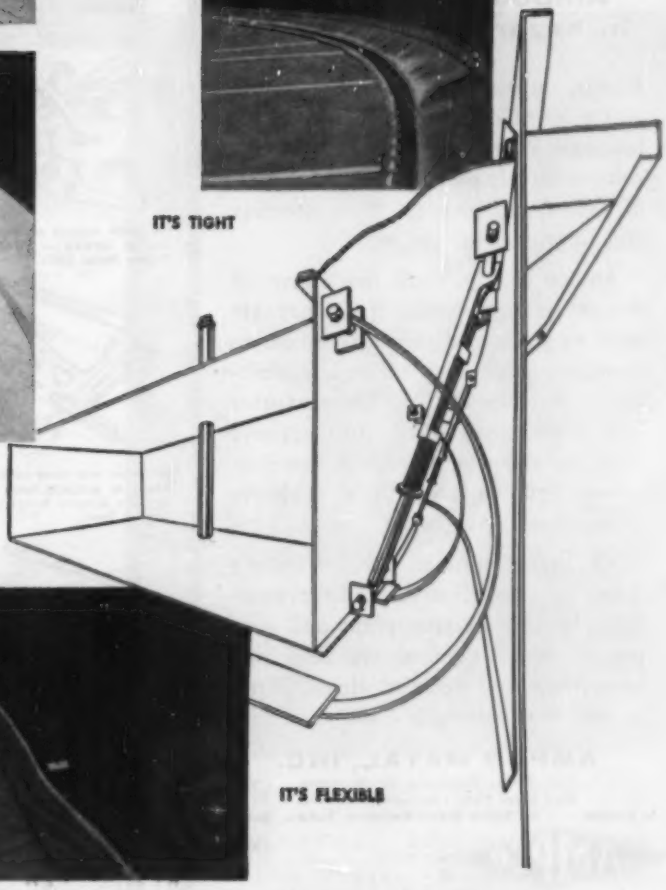
Texas—90′ x 48′—55,000 bbl. capacity

PROVED WHERE ECONOMY COUNTS...

The demands for more production and greater storage capacity with the least investment has attracted a number of well-known companies to the new low-cost Graver under-deck center-weighted floating roof tank. The typical installations at the left show the obvious advantages of Graver's new clear-deck single roof in all climates.



IT'S TIGHT



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For tools to be used in the vicinity of acetylene or similar gases, specify Ampco Monel* Tools.
*T.M. International Nickel Co.

symposium on additives in lubricating oils, that production of ashless detergents will grow from the present 1,000,000 lb a year to 40,000,000 lb in 1960. He warned, however, that increased production in Europe would hold exports at present levels or reduce them. Dr. Aries had estimated dosages and value of additives in lubricating oils for the U. S. in 1956 as follows:

	Dosage	Million Dollars
Detergents	2—10%	66
Antioxidants and Corrosion Inhibitors	0.4— 2%	22
V. I. Improvers	0.8—10%	31
Pour Point Depressants	0.1— 1%	12
E. P. Agents	5—10%	16
Defoamants	0.0002—0.07%	—
Antirust Agents	0.1— 1%	—
Oiliness Agents	0.1— 1%	3
Fluorescent Dyes	0.1— 1%	—
Total of Major Products		150
Minor Products and Exports		23
Total U. S. Production and Exports, Millions of Dollars		173

Addition of Small Amounts of Lead, Bismuth, or Thallium Speeds Sweetening of Cracked Gasoline

Work done by Tidewater Oil Company has shown that addition of small amounts of lead, bismuth, or thallium to caustic used for air-caustic sweetening of inhibited light catalytic naphthas will increase the rate of conversion of mercaptans to odorless disulfides. The process has been used successfully on a commercial basis by injecting doctor solution into the caustic. Rapid conversion of the mercaptans, which enter into and catalyze gum formation reactions, results.

New Inhibitor for Rust Formation in Transportation, Storage Facilities Described

Car owners also will benefit from a new rust inhibitor that can be added to gasoline to stop rusting in tankers, pipe lines, and storage tanks, according to Robert M. Pines, a chemist for Alrose Chemical Company. Laboratory tests show that it will stay in sufficient concentration to protect iron and steel surfaces contacted by the fuel in an automobile.

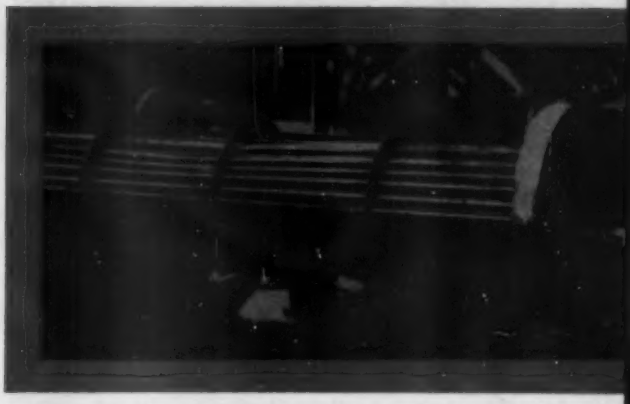
The new product, called n-oleoyl sarcosine, can be dissolved in either petroleum or synthetic lubricants and leaves no ash when burned. Tests have indicated that the liquid additive resists leaching by sea and fresh water.

OTHER PAPERS presented covered a wide variety of topics, ranging from delicate techniques for analysis of hydrocarbons in complex mixtures, to synthesis of complicated compounds. Preprints of the papers given at the general sessions as well as the symposiums are available from the American Society, Division of Petroleum Chemistry, 2424 Evarts Street, N. E., Washington, D. C. ★ ★ ★

the high price of

SALT

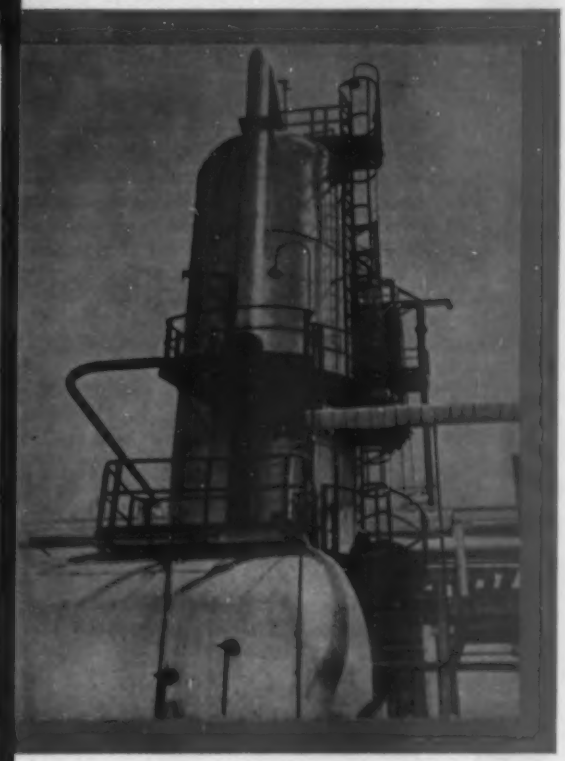
is lost on-stream time



Usually considered a cheap household necessity, salt often is an expensive refinery nuisance. In the refinery, salt causes plugging, fouling and scaling, and is the source of evolved hydrochloric acid, a destructive corrodant. While plugging, scaling, fouling and corrosion are costly in the corrective measures they make necessary, the real cost is in lost time-on-stream.

Salt troubles are best eliminated by preventing salt from entering the refining equipment. Tretolite Chemical Desalting removes salts from the charging crude in the 98 to 100 per cent range. Tretolite Desalting also removes proportionate amounts of abrasive and plugging elements such as "fines,"—sand, silt, rust particles, etc. In addition, the "washing" action in Tretolite Chemical Desalting eliminates proportionate quantities of arsenic, a damaging catalyst poison.

Don't pay the high price of a salty crude charge. Your Tretolite Refinery Service Engineer will be glad to discuss the advantages of refining salt-free, washed crude. Why not call him today?



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II. SELECTING EQUIPMENT

E. Mechanical Shaft Seals Their Pressure – Velocity Limitations

Ralph E. Morgan and Herbert B. Hummer
Chief Engineer *Research Director*
Durametallic Corporation

FOR a number of years mechanical seal manufacturers have recognized the need for seals to cover the widest possible pressure ranges. For this reason, seal designs have fallen into two basic categories: "balanced" and "unbalanced."

Recent evaluations have shown that velocity is as important as pressure in the performance of mechanical seals. As a matter of fact, it has been established that with relatively low velocities unbalanced seals can be used at relatively high pressures. Also, that when velocities are high, balanced seals are required even at relatively low pressures.

In the past, pressure limitations of unbalanced seals have been established arbitrarily at constant figures regardless of size, speed, mating face materials, or liquid handled. Some seal manufacturers have used the figure 200 psi, others 150 or 100 psi for unbalanced seals. Some refineries even went to standards that required the use of balanced seals whenever the pressure in the stuffingbox exceeded 50 psig. These pressure limitations were established largely from field experience.

Until recently this was the only method that was available; however, a thorough study of the problem has revealed what some have long suspected is true, namely, that other factors such as shaft (or seal) size, peripheral speed, contact mating face materials, as well as the characteristics of the liquid handled, all are important factors.

It is not to be expected that for a specific pressure and liquid that an unbalanced 3-in. shaft seal operating at 3500 rpm would have the same life expectancy as a 1-in. shaft seal operating under the same conditions at 1750 rpm.

In order to have a better understanding of the reason for establishing pressure limitations on unbalanced seals, and, as a result, the point where balanced seals are required, a brief explanation, as well as an understanding of the meaning of these terms, is necessary:

On unbalanced seals (Fig. 1) the total pressure or closing force (B) acts on the total contact area of the mating faces. This pressure plus spring load forces the rotating face against the stationary face. A film of liquid is formed (C) between the faces, which provides seal face lubrication. This film has a pressure gradient and enters between the faces at stuffingbox pressure and leaves the faces at atmospheric pressure. The film pressure tends to separate or force the faces apart; however, as shown in Fig. 1, this pressure exerts considerably less force than the total pressure closing force. A net force acts against the faces which increases as the stuffingbox pressure is increased. When face pressures reach the point where no film remains, or where excessive face loads are imposed that are unsuitable for the materials of construction, excessive wear and heat will occur. It is at this point that stuffingbox pressure must be utilized to reduce face pressure, and this is termed "balancing a seal."

Balancing is accomplished by the relation or location of the mating faces. This is provided either by machining a step or shoulder in the shaft or sleeve, or by providing the same feature within the seal design as shown in Fig. 2 and 3. Diameter "A" is known as the balance line or diameter.

In order to clarify we will consider first a seal that is overbalanced and the reason for its being overbalanced (Fig. 4). Like the unbalanced seal, the stuffingbox pressure acts against the mating faces "B" on balanced seals in exactly the same way. The stuffingbox pressure, however, also acts on the opposite of the face "B." Therefore, the area beyond balance diameter "A" is in perfect hydraulic balance. Once again, as in the case of the unbalanced seal, a film with a pressure gradient (C) exists between the seal faces. As the seal faces in this hypothetical case are in perfect static hydraulic balance, the pressure existing between faces will force the faces apart, provided the spring force is less than the force resulting from the pressure gradient. This explains the reason why balanced seals are in reality only partially balanced, as shown in the following examples:

To avoid the above overbalanced condition, it is necessary to create a pressure area that is sometimes termed "unrelieved area." To accomplish this, the stationary face must be so located in relation to the rotating face that the OD is greater than the balance, diameter "A." (See Fig. 2 and 3.) Areas beyond the OD of the stationary face are balanced, therefore, the total closing force (stuffingbox pressure plus the spring load) acts only on the area between balance (diameter A) and the stationary face OD; to increase balance, the OD of the stationary face is reduced in

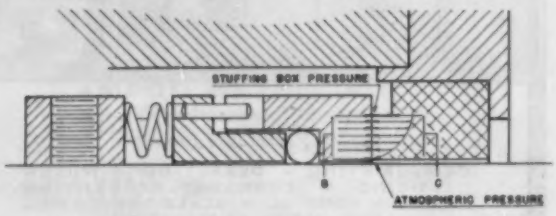

FIG. 1. Diagrammatic presentation of an unbalanced seal.

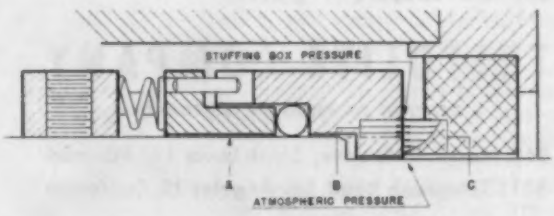

FIG. 2. Diagrammatic presentation of a balanced seal.

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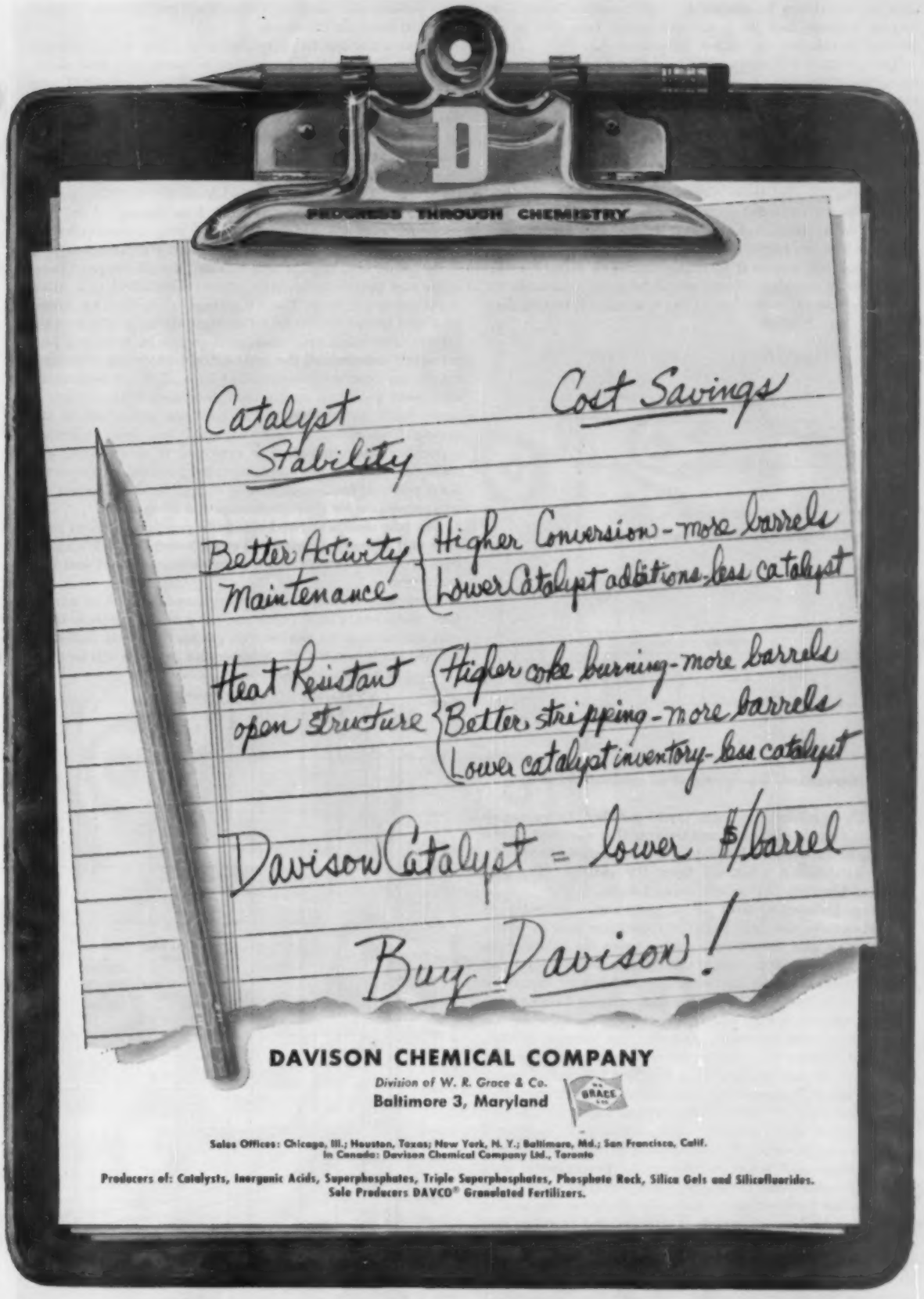

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relation to balance (diameter A) and to reduce balance or impose greater face load, the stationary face OD is increased in relation to balance (diameter A).

The question will probably arise as to the reason for not using balanced seals for all applications and forget about the unbalanced design altogether. As outlined above, the closing forces acting to keep the faces together must always be greater than the opening force that is created by the film pressure on the seal faces.

Unbalanced seals have been used for many years, providing long life and trouble free service on many applications. When trouble did occur, it was sometimes due to excessive wear, friction heat, etc., which was usually encountered on the larger shaft size seals, proving that it was impossible and unsound to make claims or recommendations that an unbalanced seal would be equally suitable for a given pressure, regardless of the size, speed, mating face

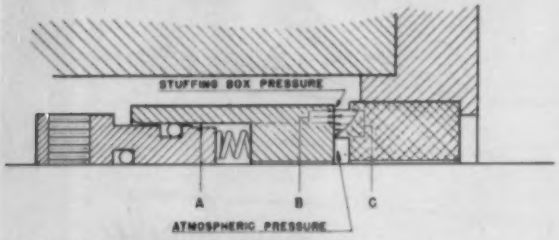

FIG. 3. Another arrangement of a balanced seal.

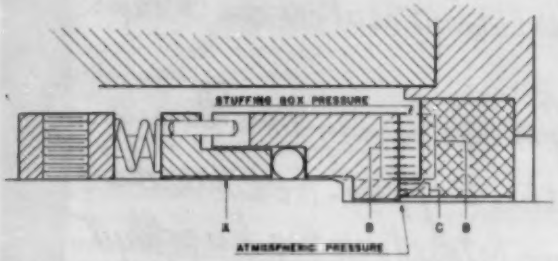

FIG. 4. Diagrammatic presentation of an overbalanced seal.

materials or construction, and liquid handled. An extensive study and evaluation was undertaken that resulted in the running of hundreds of laboratory tests and many field tests, which established what we term PV ratings (Pressure Velocity Limitations) on unbalanced seals.

Before proceeding with actual tests and evaluations of face materials, the first important decision was to establish what liquids should be used to insure the establishing of pressure limitations that could be considered sound and conservative. Because the liquid handled has an important bearing upon seal life due to the film existing between the seal faces, it also is easy to visualize the number of tests that would have been necessary, and the vast amount of data compiled, if tests were conducted on even a small percentage of all the liquids commonly handled by seals. Liquids such as nitric, hydrochloric, and sulfuric, and many other acids in addition to many hydrocarbons including gasoline and propane, while not lubricants, actually do support a better film between seal faces and have better lubricity than most waters and water solutions. As preliminary tests proved that less wear at the seal faces occurred when handling gasoline than untreated water for the same size seal at the same speed and pressure, it was decided that two sets of curves would be established, one for water and water solutions and the other for liquids that could be considered at least equal to gasoline in lubricity. This would be conservative for many acids and corrosive liquids; although they present corrosive problems they still provide a good seal film between the faces.

Untreated water has a tendency to plate out or deposit iron, lime, and other impurities between the seal faces. This condition is noticeable at temperatures over 100F, and the higher the temperature the greater the amount of impurities that plate out. All tests were run handling water at an average temperature of 140F, and gasoline at ambient room temperature of approximately 80F. Test facilities used to establish PV ratings involved the use of five test stands. Shaft speeds were varied from 870 to 7800 rpm on various sized shafts ranging from 1 in. through 4 in., and pressures were varied from 25 to 350 psig to determine the desired results and establish curves and PV ratings.

By conducting tests in this manner, a wide range of pressures and peripheral speeds could be obtained in a minimum amount of time. The PV ratings established are based on a seal life of 15,000 hr either continuous or intermittent service. The total wear measured on one or both seal face materials determined the established limitations. The limitations on wear were established by seal design because as face wear develops, spring load decreases. The amount of wear must not, therefore, exceed the point where the spring load is insufficient to keep the faces together, especially when pressure is removed from the box, and sufficient spring load must also be present to overcome shaft packing friction or torque along the shaft, as well as to compensate for shaft deflection and whip.

Our test results showed a definite relation between pressure and velocity (peripheral speed) and that a PV rating figure could be established for any combination of seal face materials.

Tests were conducted on many combinations of mating face materials. For explanation purposes, a ceramic face* and stellite running against two grades of carbon materials, termed No. 9 and No. 12, in water and gasoline will be used.

*Duramic is Durametallic Corporation's product — Ed.

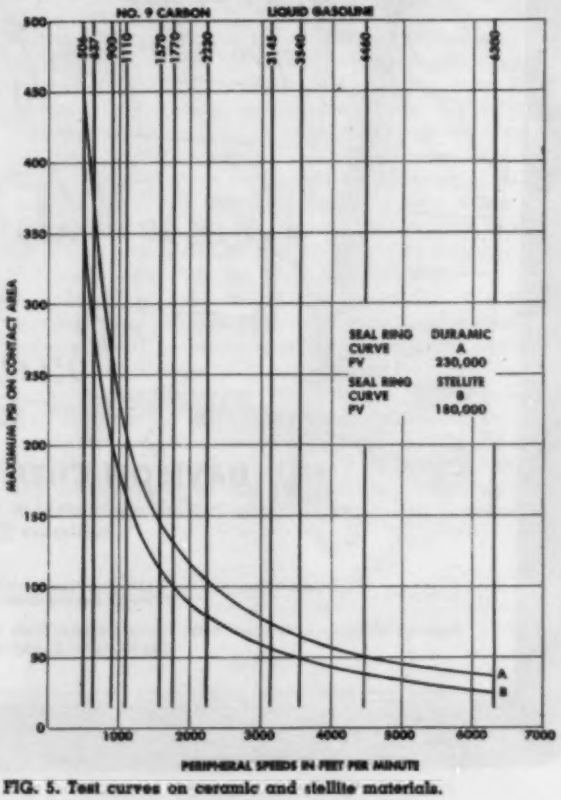

FIG. 5. Test curves on ceramic and stellite materials.

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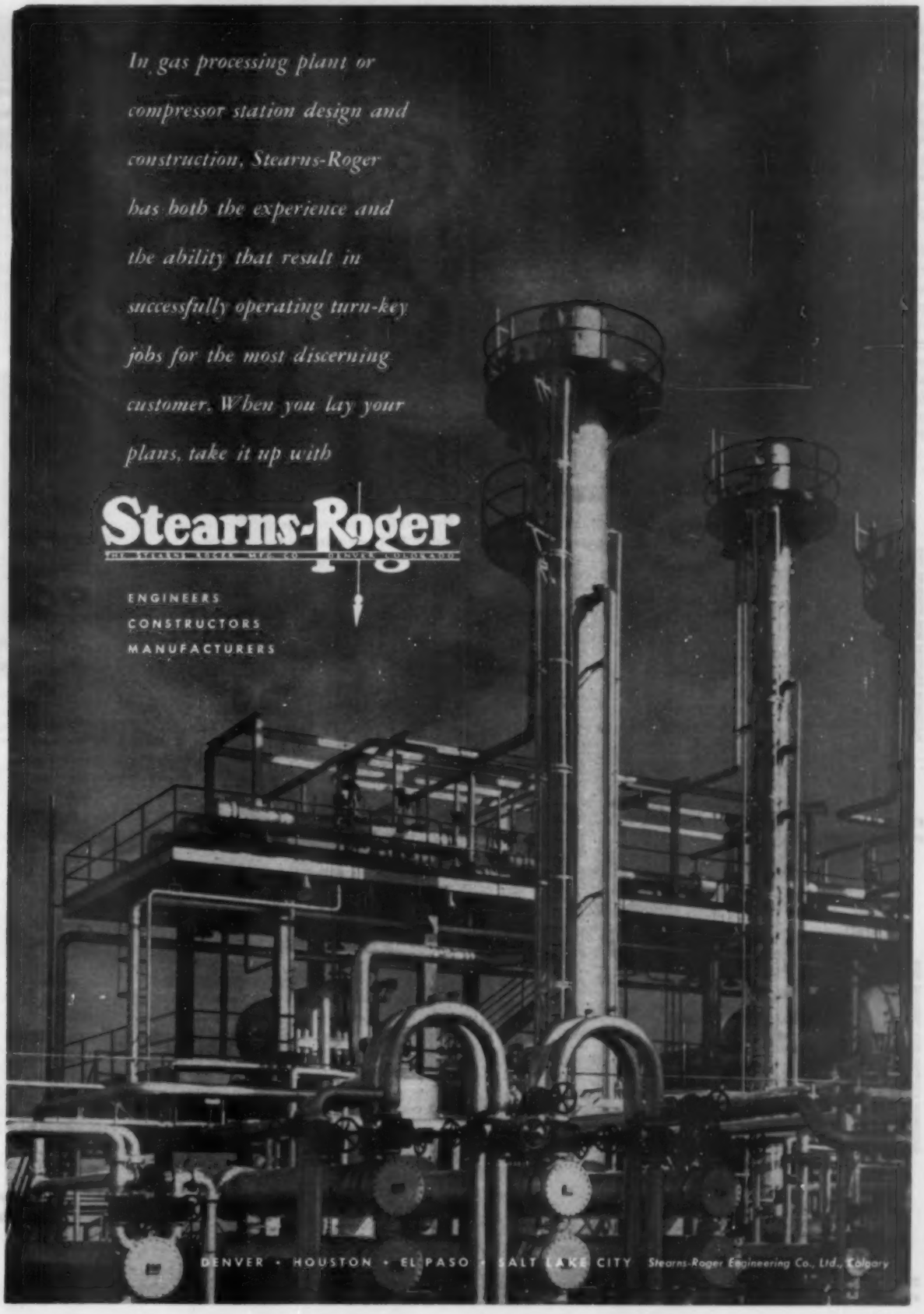
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There are various grades of carbon materials that have a definite purpose, requirements, and limitations. Many metallic impregnated carbons, such as babbitt, bronze, copper, silver, cadmium, all have their place for specific applications. The two carbon grades that will be discussed in this article are both non-metallic grades, but differ widely in physical properties. The No. 9 carbon is a hard, dense material 100 scleroscope hardness 1.7 average apparent density. The No. 12 carbon is softer, not so dense, 55 scleroscope hardness 1.4 density. Both are very good bearing materials. The No. 9 material is superior but it is a more expensive material and is more difficult to machine.

A typical example of one of the many actual test data curves compiled is shown in Fig. 5 — ceramic and stellite running against No. 9 carbon in gasoline, which we consider a lubricant. This curve as shown is plotted in peripheral speeds in feet per minute against the maximum psi on contact area of seal faces. The PV ratings as shown and established, 230,000 for ceramic and 180,000 for stellite established the pressure limitations. These figures, as previously stated, were determined by wear, friction heat, and face conditions. By dividing, the peripheral speed is based on the OD of the stationary face and not the shaft diameter. For example, the actual peripheral speed of a 2-in. shaft would be 1880 ft per min, whereas the speed, based on the OD of the stationary face, is 2230 ft per min.

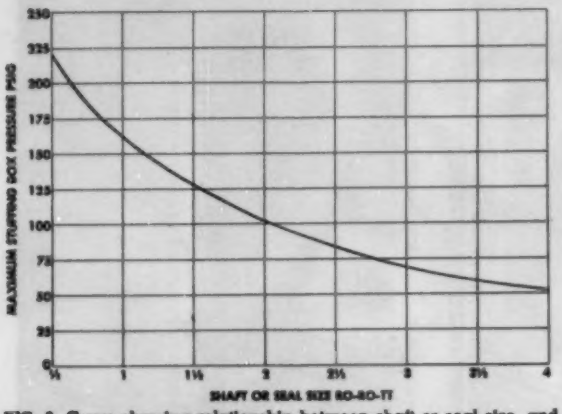

FIG. 6. Curve showing relationship between shaft or seal size, and stuffingbox pressure (3500 rpm).

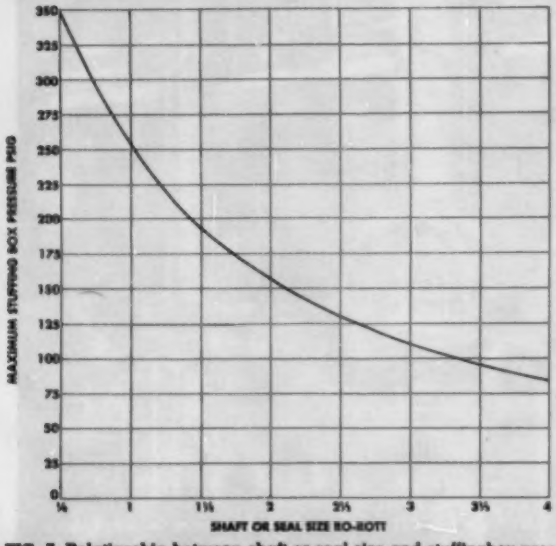

FIG. 7. Relationship between shaft or seal size and stuffingbox pressure (1750 rpm).

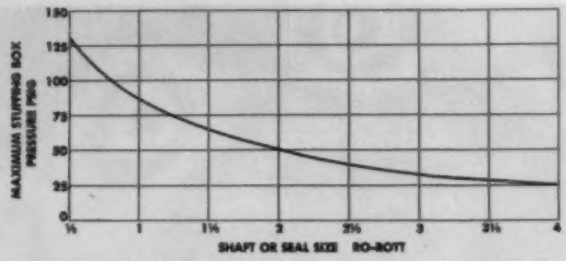

FIG. 8. Curves similar to those shown in Fig. 6 and 7, operating on non-lubricant fluids.

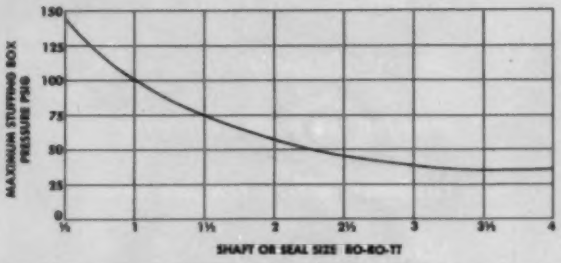

FIG. 9. Pressure-velocity-seals size relationships operating at 3500 rpm on gasoline and similar fluids.

By dividing the established PV rating by the peripheral speed in feet per minute, the maximum psi on contact area faces is obtained. For example, by referring to Fig. 5, an unbalanced seal handling a liquid with lubricity of gasoline or better, operating at 2230 ft per min, would have a maximum pressure limitation of $\frac{230{,}000\ PV}{2230\ ft/min} = 105$ psig based on ceramic and No. 9 carbon face materials.

As most applications for seals are applied on pump apparatus at 1750 or 3500 rpm, the need for curves showing pressure limitations based on various shaft seals at these two speeds were compiled from original data shown in Fig. 5. These curves eliminate the necessity of figuring peripheral speeds on the most common speeds encountered. For speeds other than 1750 and 3500 rpm, curves per Fig. 6 are required.

Examples of a few of the curves plotted showing shaft seal size and maximum pressure are Fig. 6, 7, 8, and 9. By referring to Fig. 6, for example, it is found that a 1-in. shaft size seal would be suitable for 160 psi, whereas a 3-in. shaft seal would be suitable for only 70 psi.

These data give a clear picture for the selection of either a balanced or unbalanced seal for a given set of conditions.

For pressure above those shown on the curves, a balanced seal is recommended with a face load within the pressure limitation of the unbalanced seal. For example, by referring to curve (Fig. 6) a 2-in. unbalanced seal is shown with a maximum pressure limitation of approximately 100 psig. For any pressure over 100 psig, a balanced seal would be recommended. By further reference to this same curve, the maximum pressure limitation on a 3½-in. shaft seal is established at approximately 60 psig, and for any pressure above 60 psig, we would recommend a balanced seal.

A brief summation can be made with the statement that unbalanced seals can be used at relatively high pressure, and by the same reasoning, balanced seals are required at relatively low pressures.

Author's Note

In the interest of extending the working life of mechanical seals an extensive study was made in the laboratories of Durametallic Corporation. This article is a report on that study.

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PETROLEUM CHEMICALS DIVISION
NEWS

CONTINUED *Estersil GT*

ports that the use of an estersil-based grease has caused his maintenance costs on a group of cutting machines to drop from .185 cents per ton to less than .09 cents per ton—a 50% saving.

Many users report that equipment runs much cooler and quieter with estersil-based greases.

In addition to heavy-duty industrial applications, estersil greases have been used in several automotive applications. In passenger cars, test engineers

THIS DEMONSTRATION dramatizes the unusual water resistance of estersil greases. They can be immersed in boiling water for long periods without breakdown.

report, these greases greatly prolong the smoother, easy-riding effect of a fresh lube job.

In heavy-duty earth-moving equipment, estersil greases often provide significant savings in downtime and maintenance costs. In some instances, crane and shovel operators reported an almost immediate cessation of leakage from hoist drum bearings on to the brake bands after switching to estersil grease.

Exceptional water resistance

Du Pont Estersil GT is an entirely *new type* of grease thickener. It is a pelletized form of finely divided amorphous silica. One of its unique features is that each minute particle is enveloped in a chemical "raincoat" which gives estersil-based greases positive, built-in water resistance and eliminates the danger of washout.

Continued middle next column

ASSISTANT TO THE SALES MANAGER—ADDITIVES

RICHARD O. BRAENDLE joined the Du Pont Company in 1944 after receiving his B.S. degree in Chemical Engineering at Massachusetts Institute of Technology.

He was first assigned to the Grasselli Chemicals Department's Experimental Laboratory in Cleveland. There he did development research on inorganic chemicals, mainly estersils. In 1950, he was transferred to the Du Pont Experimental Station in Wilmington where he worked on the application of estersils as grease thickeners.

He joined the Technical Section of the Petroleum Chemicals Division in 1952, continuing his product development work on estersil GT. During 1955 he did market research analysis for a number of petroleum additives which led to his current assignment as assistant to the sales manager for additives.

During World War II, Mr. Braendle served in the U. S. Army as a researcher and supervisor of a manufacturing operation on the Manhattan Project. He is a member of the American Chemical Society and the American Society of Lubrication Engineers.

RICHARD O. BRAENDLE

ESTERSIL GT greases stand up unusually well even under the combined action of intense heat and vigorous mechanical working.

Excellent heat and shear stability

Estersil greases are non-melting, and extremely wide temperature ranges produce little change in their consistency.

Even under prolonged high-shear, high-temperature operating conditions, greases made with Du Pont Estersil GT show outstanding resistance to mechanical breakdown.

Handling qualities

Greases thickened with estersil can be easily handled in any application—because their unusually high thermal and mechanical stability permits use of a much softer grease.

Estersil greases can be easily made, too. A milling operation is all that is required because of the completely synthetic, preformed thickening structure of estersil GT.

A Du Pont Petroleum Chemicals Division representative will be glad to give you more detailed information on estersil GT. Contact any of our sales offices listed below.

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PETROLEUM CHEMICALS DIVISION

NEWS

November ★ One of a Series of Bulletins for the Petroleum Industry ★ 1956

Du Pont uses sports car to study fuel-injection related to product development

Although sports cars are designed for road racing or as a highway hobby, the Du Pont Petroleum Laboratory is now using one for an entirely different purpose.

With an eye to future automotive fuel requirements, the laboratory is now fitting out a new Mercedes-Benz, 300 SL, with special instrumentation. The objective is to investigate the additive needs of fuels for fuel-injection engines and to test promising candidates under actual road conditions. The Mercedes-Benz was picked for this work because it is the only car with a fuel-injection engine that is commercially available in this country.

Mercaptide problems solved with DMD

If you are not now using Du Pont Metal Deactivator in your heating and diesel fuels, we believe you will be interested in the success of other refiners who have used it.

Several years ago, for example, a major oil company was having copper mercaptide problems. They encountered the trouble in both straight-run diesel fuel and No. 2 fuel oil composed of 95% straight-run and 5% Houdry cat-cracked.

To solve the problem, 2 pounds of DMD per 1,000 barrels were added to both fuels. This proved highly successful for several seasons. Then the use of DMD was discontinued. The trouble recurred. So DMD was again added, and this company's mercaptide problem was again under control.

Another major company encountered gel-clogging complaints in the Spring of 1955. The trouble involved a No. 2 fuel oil composed of fluid cat-cracked and straight-run. The cracked component varied in composition from 75% to 90%.

During the next heating season, the company added 2 pounds of DMD (in combination with Du Pont Fuel Oil Additive No. 2) per 1,000 barrels. There were no complaints of mercaptide formation reported the following season.

These are only two of the many success stories reported by refiners using DMD to combat mercaptide problems and complaints. And many refiners have found that since the cost of adding effective amounts of DMD is so low, it pays to use it as an "insurance" against copper contamination in a wide variety of products.

Greases containing Du Pont Estersil GT prove highly successful in many types of service

It was about two years ago that Du Pont estersil grease thickener was first introduced.

Since then, millions of pounds of grease made with this unique thickening agent have been used in a wide variety of industrial and automotive applications. And the success obtained with these greases has been truly outstanding.

Photo courtesy Joy Mfg. Co.

CONTINUOUS MINER—completely lubricated with estersil grease

One coal mining company, for example, reports that they eliminated the need for using three different mining equipment lubricants by standardizing on semi-fluid estersil-based grease in their continuous miners, loading machines and shuttle cars.

In the gear cases of the continuous miners, this company, before using an estersil grease, had a lubricant consumption of two to three *gallons* per shift. When they changed to an estersil grease, they found that the average consumption immediately dropped 75% to two to three *quarts* per shift. On loaders they actually stopped keeping records because the consumption was so small.

Longer gear life

When rebuilding machines, this same company had almost always replaced bearings and gears. But since switching to the estersil grease, they found that the gears could be used over and over again without significant wear. This was probably due — at least partially—to the fact that the estersil grease effectively sealed out moisture, dirt, coal dust and other abrasive foreign matter.

Maintenance costs down

Another user in the coal industry re-

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OVER

REFINING IN BRIEF

Improving Fuel Oils Through Addition Agents

Use of additives will increase, will permit refiner to obtain greater yields, market more stable products

W. deB. Bertolette and J. D. Rogers
E. I. du Pont de Nemours & Company

MANY present day distillate fuels, as produced, do not have sufficient storage or thermal stability to prevent the formation of insoluble residues which give trouble in oil burners, diesel engines, or jet engines. The following discussion covers problems caused by instability which are confronting the consumers of distillate fuel oils and shows the benefits to be derived from the use of additives.

I. Furnace Oils

In the case of domestic heating oils, which represent the largest bulk of the distillate fuel oil market, the problem today is largely one of stability. This has been brought about by the increased use of catalytically cracked stocks in place of the straight-run stocks previously burned. Although the catalytically cracked stocks are as good or even better than straight-run stocks in heating value, they are generally less stable in storage. Also, when blended with straight-run or thermally cracked stocks, they frequently exhibit incompatibility. This leads to formation of soluble gums or insoluble residues which can be quite troublesome.

An unstable No. 2 furnace oil will deposit sediments in refinery storage tanks, in transportation equipment, at distribution points, or in the actual burner and cause inconvenience to the burner primarily affected are the filters, screens, and nozzles. Most domestic and larger heating installations contain a filter, a pump strainer, and a nozzle strainer. The plugging of these filter devices will, of course, stop flow to the burner and cause inconvenience to the consumer as well as maintenance costs. The filtering devices are used to protect the very fine tangential slots and very small orifices in use with the high pressure gun-type burners which represent approximately 85 per cent of domestic installations. Where insufficient filtering has been designed and installed in the burner setup, nozzle plugging by the sediment will result. Nozzle plugging may also occur with unstable fuels which form insoluble residue while residing in the nozzle section for the relatively short times between heating cycles at high temperatures. Furnace installations using rotary-type burners with gravity flow do not have a nozzle to plug, but in these systems the deposit difficulties occur instead of the float mechanism, in the rotating fuel spray outlet or on the flame ring.

Difficulties with fuel stoppages due to residues from fuel instability can be overcome in a number of ways. Segregation of fuels in storage or inert gas blanketing of storage helps minimize the formation of these residues. Treating processes such as caustic washing, acid washing and solvent extraction, and refining processes, such as hydrogenation, will almost always result in improvement in stability. The use of additives in place of, or along with, these processes has proved to be the most economical solution in most cases, however. In Figure 1, a fuel which is quite susceptible to improvement by caustic washing showed the reduction in residue formation during storage that can be brought about by this treatment or the use of an additive or both. A

Editor's Note — The figure numbers in this brief article are not the same as given in the original paper.

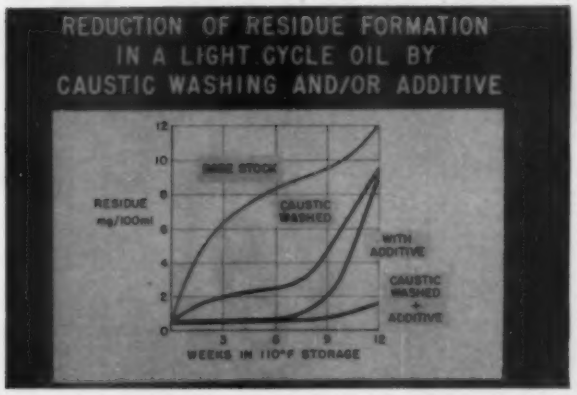

FIG. 1. **Reduction of residue** formation in light cycle oil by caustic washing, and/or additive.

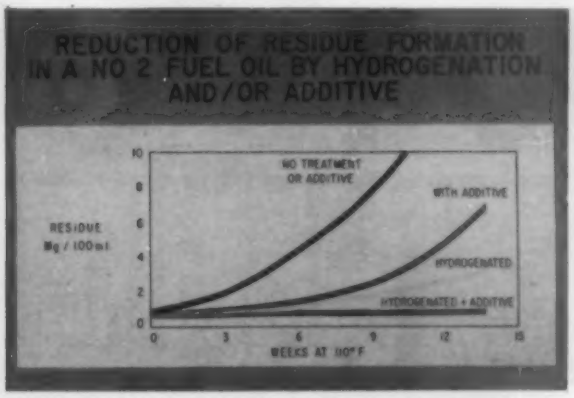

FIG. 2. **Reduction of residue** formation in No. 2 fuel oil by hydrogenation and/or additive.

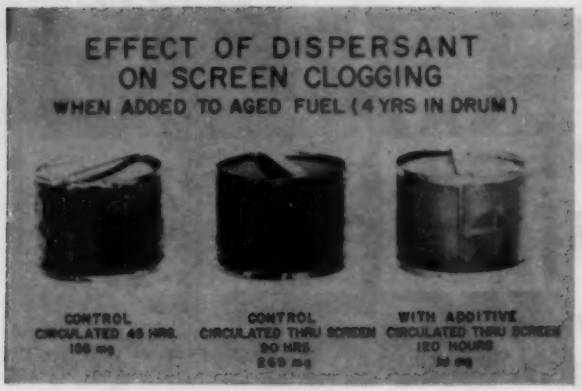

FIG. 3. **Effect of dispersant** additive on screen clogging by a four-year old fuel.

FIG. 4. **Reduction in diesel** filter plugging, using dispersant type additive. (On cat cracked "economy" diesel fuel).

similar comparison of the increase in stability of a fuel brought about by hydrogenation and by the use of an additive is shown in Figure 2. A residue content of 2 mg/100 ml is generally sufficient to cause plugging difficulties in fuel systems during use.

It is estimated that 70 to 80 per cent of the furnace oil being sold today contains an additive to provide improved stability. The additives in use are of several general types—metal petroleum sulfonates, polar polymers, alkyl amines, or combinations of these, sometimes with formaldehyde. Some are effective in a wide variety of fuels while others may be effective in only a few fuels. These additives, of which there are a number offered commercially, are primarily inhibitors to reduce residue formation or dispersants to reduce particle size and improve filterability. Figure 3 shows the dispersing effect of an additive on residues which were already present in an aged fuel.

Some additives also will provide a degree of color stability to the fuel, and some have the additional property of being good corrosion inhibitors. This property is important in pipe lines or other transportation equipment, although the problem in domestic heating tanks is primarily one of corrosion by water bottoms in the tank and is best combatted by use of an aqueous phase corrosion inhibitor.

An entirely different cause of plugging in home burners is that caused by the formation of gels. These gels frequently are clear and gelatinous in appearance, although they may also appear waxy, or rubbery. It has been shown that they are caused, in many cases, by a reaction between soluble copper, from either copper or brass metal parts, and the mercaptans present in the fuel oil to form copper mercaptides which may either precipitate out as a wax coating or form a jelly-like deposit which is composed of approximately 0.1 to 1.0 per cent copper mercaptide and over 99 per cent fuel oil.

It has been found that metal deactivators of the salicylidene propanediamine type when added to the fuel in low concentration will prevent the formation of this type of gel. It is theorized that this result is accomplished through chelation of soluble copper. Removal of reactive mercaptans from the fuel by caustic washing or sweetening is another way of overcoming the copper mercaptide gel problem.

II. Diesel Fuels

Diesel fuels encounter the same problems resulting from insoluble residue buildup in storage, shipment, and use as have been mentioned in the preceding section under furnace oils. In many cases the same product is sold for both uses. In addition, where the end of the fuel is in a diesel engine, there exist the special problems of injector sticking, combustion chamber deposits causing wear, and the need for good ignition porperties. Because of the cetane number requirement, diesel fuels continued to be composed of straight-run products for a longer time than did furnace oils. However, today diesel users have discovered that in many cases they can operate satisfactorily with fuels of lower cetane number. Therefore, catalytically cracked stocks are being increasingly used for this purpose.

The current trend toward the use of economy diesel fuels has created a

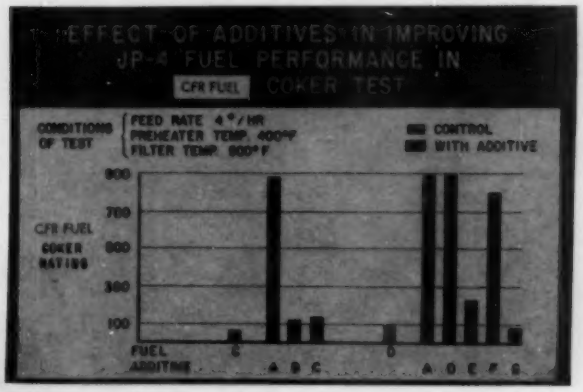

FIG. 5. **Improvement effected** by additives in JP-4 jet fuel performance in CFR coker test.

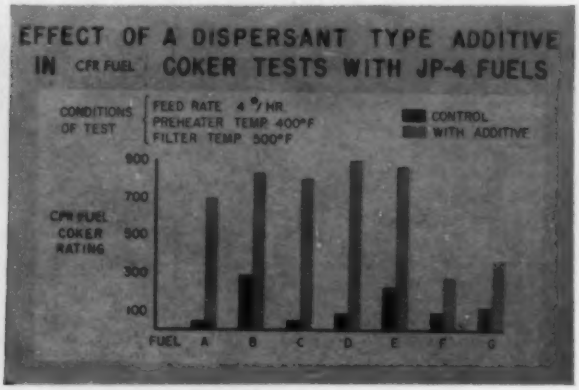

FIG. 6. **Improvement effected** by a dispersant type additive on a JP-4 jet fuel in CFR coker test performance.

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INJECTOR-STICKING is the problem at hand here. In this case, a combination of Du Pont FOA-2 and Metal Deactivator proved to be the solution.

Now—a new Du Pont Service to help you solve diesel-fleet fuel problems

When a diesel operator encounters a fuel problem—such as injector-sticking or filter-plugging—he often tends to blame the refiner for his troubles. And with a big fleet operator, such complaints are likely to jeopardize a substantial amount of business. It is at this point that your customer relations can often be improved by the analysis and opinions of a third party, a Du Pont technical representative backed up by numerous Du Pont facilities.

To help you solve these problems as quickly and easily as possible, our Du Pont Petroleum Chemicals Division automotive specialists will be glad to work with your men. Their practical experience with this type of problem can be added to your own experience. And our five conveniently-located regional laboratories, as well as the main Du Pont Petroleum Laboratory, can also aid you in this work.

In cases where filter-plugging occurs—in both truck and tractor fleets—our service representatives have found that Du Pont Fuel Oil Additive No. 2 (FOA-2), or a combination of FOA-2 and Du Pont Metal Deactivator (DMD) helps overcome the trouble. This same combination of additives has proved helpful also in overcoming injector-sticking. However, since different diesel fuel stocks vary considerably in composition and response to additives, each problem must be studied on an individual basis.

Different diesel engine injector designs may also affect the performance of fuels. We are, therefore, also working with diesel engine manufacturers on injector-sticking problems.

So if you are encountering fuel problems with any of your accounts, it may pay you to discuss them with one of our automotive specialists. And you can request this service through any of our offices listed below.

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need for additives. The designation "economy diesel fuels" can cover a multitude of products, but this designation of fuel is usually understood to mean a lower cost diesel fuel with higher end point, higher sulfur content, and lower cetane number than has generally been specified before. Other properties may be less desirable also, and these fuels are offered at prices ¼ to 1 cent under the prevailing market price for diesel fuels and thus represent a large saving in fuel cost to a big consumer such as a railroad.

"Economy fuels" have suffered more from instability than from any other shortcomings, and although further treatment of such fuels would not be practical since it would probably remove them from the "economy" class, the use of an additive at relatively low cost is quite practical. One particular field test on a railroad using an "economy" diesel fuel showed that a marked improvement in filter performance occurred when an additive was used. The comparison of the cotton filters is shown in Fig. 4.

The problem of injector sticking is believed to be related to both soluble gum and insoluble residue in the fuel and it has been found true, both in the laboratory and in the field, that the use of stabilizer-dispersant-type additives will, in many cases, overcome this problem.

III. Jet Fuels

Present commercial jet fuels have been fairly satisfactory in today's jet air craft; however, they do not have sufficient thermal stability for use in the newer aircraft with higher performance engines which are used for interceptors and high altitude bombers. Fuels of improved stability are urgently needed if engine builders are to be able to obtain maximum power and efficiency from their engines. Some of the aircraft which are involved in this problem include the new Century series of fighters which fly at supersonic speeds, the B-52 bomber, and the Boeing 707 or Douglas DC-8 transports.

The problem results from the high temperatures to which these aircraft are subjected when flying at high speed. Heat removal is a problem of foremost importance. Air coolant systems become no longer practical as they impose severe drag penalties, and the boundary air is heated to over 200 F by friction and compression so that it is no longer effective for cooling. The heat comes from a number of sources, including the lubricating oil, radar equipment, hydraulic systems, and air conditioning equipment. The fuel becomes an ideal coolant for removing excess heat from the aircraft because the fuel is consumed and the products discharged to the atmosphere.

Difficulty arises because jet fuels, like other petroleum fuels, form gums and residues when subjected to high temperatures. The residues plug the fine openings in the filters and orifices through which the heated fuel is pumped. Soluble gums will form deposits on surfaces from which the fuel can evaporate, as for example, on control mechanisms and around the fuel nozzles. In addition, there is the problem of lacquer or deposit formation on the heat exchanger surfaces with lower heat transfer and flow restriction which cannot be tolerated.

These problems have been experienced with current jet fuels both in flight and in full scale engine test rigs. However, in order to make progress on this problem, it was necessary to develop a bench test which could rapidly evaluate the thermal stability of fuels. This resulted in the CFR Fuel Coker, which can provide a rapid means of evaluating the thermal stability of a fuel and its filter performance. Fuel evaluations using this piece of equipment have been found to correlate very well with a full scale engine rig at Pratt & Whitney Air Craft and also to correlate with the actual flight performance of a number of JP-4 fuels in Military Service.

In order to provide jet fuel of the necessary quality, it is possible to select stocks with high thermal stability. Fuels from different crude sources exhibit wide variations in high temperature stability. However, stock selection is rather impractical because it entails increased handling and storage problems and necessarily limits the availability.

Appropriate refining or treating processes to improve thermal stability of jet fuels would include all of the commonly used treating steps such as sulfuric acid washing, caustic washing, clay treating, SO_2 extraction, solvent extraction, redistillation or hydrogenation. These treating methods used singly or in combination could markedly increase the available stocks of high stability jet fuel if necessary. Rather severe treating processes are necessary to make some of the most unstable fuels acceptable, however. Hydrogenation processes give very significant improvements in jet fuels in this respect. These refining processes are of current interest because of the large amount of hydro-treating capacity being installed as a result of the increased availability of hydrogen from catalytic reforming units.

Additives are capable of improving the thermal stability of most jet fuels to a satisfactory level. Currently, this is considered to be at least 300 minutes in the CFR Fuel Coker to a pressure drop of 12 in. of mercury across the filter. In cases where the problem is quite severe the combination of treating plus additive may be needed to reach this level. The conventional oxidation inhibitors used in gasoline were found ineffective with respect to this high-temperature performance in jet fuels. Dispersant-type additives offered a better solution. Certain ones of this type additive have been shown to extend the time to filter plugging by 5 to 15 times. Fig. 5 shows the effect of several commercially available stabilizing additives on the performance of the JP-4 fuel in the CFR Fuel Coker test. Fig. 6 shows the effect of one dispersant-type additive in a variety of JP-4 fuels in the same test.

The polymeric dispersant additives, which have been effective in the stabilization of furnace oil or diesel fuel stabilization, have proved to be effective in jet fuels as well. This may not be too surprising in view of the fact that jet fuel deposits are quite similar to domestic burner deposits in their composition. Typical analyses are compared in Table 1. The additives do not alter the chemical composition of the deposits, but reduce the amount of deposition and cause alterations in physical structure which give improved filterability. It has been found, as in other

TABLE 1. ANALYSES OF DEPOSITS FROM JP-4 JET FUEL AND FROM NO. 2 HEATING OIL.

Element	Jet Fuel: Burner Nozzle	Jet Fuel: Lab Glass G oil	No. 2 Heating Oil
Carbon	49-55	67	50-85
Hydrogen	6.5-8.5	6	5-10
Sulfur	7-8.5	4	1-10
Nitrogen	2-5	2.5	0.5-6
Oxygen	15-20	14	6.27
Ash	7.5-18	7	6-20

types of fuel oil, that an additive which may be quite potent in one type of fuel may have little or no effect in another refinery's base stock.

General

When applying additives to a fuel stability problem, it is of importance that new problems must not be introduced. Some additives will show a tendency toward formation of emulsions when the fuel is agitated in contact with water and this necessitates careful handling. The introduction of a metallic component is generally undesirable as it could contribute to ash deposits which can seriously affect engine or burner operation.

Summary

In summary it appears that, in the future, the need for additives in fuel oils to satisfy the consumer's requirements will continue to increase. Even though hydrogen treating processes will be used more widely for fuel oils and will improve the quality of these fuels, there will be at the same time an increase in the extent and severity of cracking. Also there will be a growing use of high sulfur crudes which unfortunately give products which have poor stability and need more treatment. Additives will continue to be useful for improving the stability of the cracked stocks, for overcoming incompatibility between fuel stocks or blends or for providing properties not inherent in the fuel such as dispersancy. Additive treating is a relatively simple operating procedure and the economics are frequently quite favorable when compared to the cost of refining or treating processes. Because of this, additives represent a ready means of providing maximum availability of fuel stocks with satisfactory stability. ★ ★ ★

P 830.

Volatility, Viscosity And V. I. Improvers Affect Oil Consumption Strongly

R. L. Overcash, W. Hart, and D. J. McClure
Kendall Refining Company

CONSUMPTION rate is an important property of a motor oil by which a motorist judges the oil's quality. It is a property on which he can readily make personal observations. Control of oil consumption for a given engine condition is largely a matter of oil compounding. Heavier grades of oil reduce consumption. Lighter grades of oil cause increased consumption due to their viscosity and the increased volatility of the lighter components used in their compounding. Multigraded oils may have unusual consumption characteristics due to the action of viscosity index improvers used in their compounding

Data are presented from laboratory oil consumption tests using a 6 cylinder L-head engine. A test of 6 hours duration was found to be sufficient to establish a firm rate of consumption. The engine was run at 3150 revolutions per minute and either 30 or 60 brake horsepower.

The volatility of neutral or distillate lubricating oil stocks has been investigated. The viscosity of 100F of the neutrals ranged from 42 to 170 sus and each was a close cut fraction. The mid point of the boiling range at 10 mm of mercury varied from 338 to 535F.

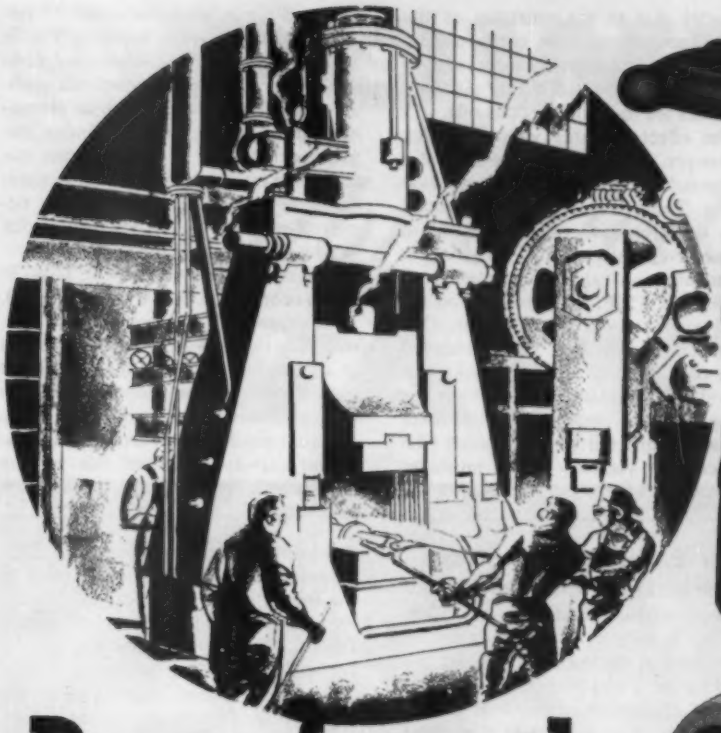
In studying neutral volatility, two factors influence the results: 1. the ease with which the neutral molecule may be evaporated and 2. the relative number of neutral molecules present. The ease with which a molecule may be evaporated is a function of its size and type. The smaller the molecule the easier it can be evaporated. Also, the greater the relative number of neutral molecules, the greater the rate of evaporation. Therefore, if volatility due to the neutral molecule is to be studied, it is desirable to hold the relative number of such molecules constant. This is known as constant mole per cent and is a different concept than constant volume per cent that has been used in previous oil consumption studies.

Each of five neutrals was blended into an oil with a viscosity of 2 centistokes at 350F. Each oil contained 90 mole per cent of neutral. An oil considered to be non-volatile was used to establish a reference rate of consumption. In Fig. 1, the viscosity of the light component used in each oil is shown across the bottom. At the left is shown the relative consumption of each oil with respect to the reference oil. The increased relative consumption observed with oils containing lower viscosity neutrals is assumed to be due to the increased volatility of these neutrals. The data obtained at 30 hp show an appreciable increase in consumption for neutrals of less than about 60 seconds at 100F. Under 60 hp test conditions, increased consumption is observed for neutrals of less than about 75 seconds at 100F.

It was believed that oxidation during these six hour tests was negligible. Therefore, any viscosity increase observed would be due to loss of light component. These oils losing greater amounts of light component should show greater viscosity increase. The oil that contained the lightest neutral had a viscosity increase of 245 per cent at 100F. On the other hand, the oil with the heaviest neutral had a viscosity increase of only 10 per cent. The viscosity increases for the other oils correlated very closely with their relative consumptions.

Vacuum distillation data on these oils show break points, or sudden increases in distillation temperature, after the most volatile component has been removed. The change in this break point is an indication of the amount of light component lost due to selective

Condensed by the authors from the paper, "How Do Volatility, Viscosity, and V. I. Improvers Affect Oil Consumption?" presented before the Society of Automotive Engineers, January 9-13, 1956.



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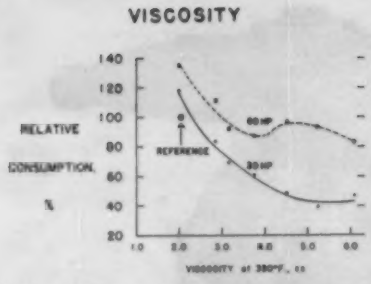


FIG. 1. **Effect of volatility,** as indicated by S.U.S. viscosity of neutral oils on consumption of crankcase oils in service.

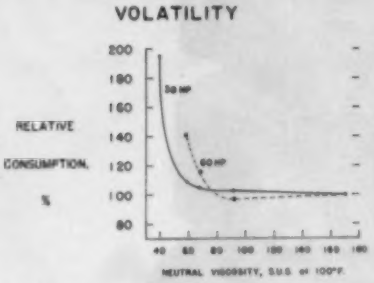


FIG. 2. **Centistokes viscosity** shows differences in consumption curves at low and at high speeds.

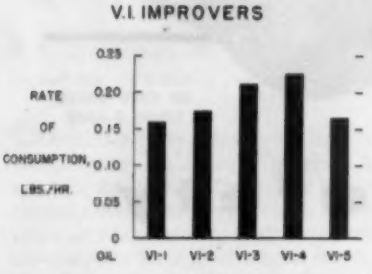


FIG. 3. **Graphs showing effect** of different V.I. improvers on consumption.

volatility. For the oil with a relative consumption of 195 per cent and viscosity increase of 245 per cent the change in break point was 18 per cent after six hours in the engine. The change in break point for the next higher viscosity neutral was about 8 per cent. The heaviest neutral showed no change in break point, indicating no selective volatility.

The effect of viscosity on oil consumption was investigated using oils of constant volatility. These oils included SAE 10W to higher than SAE 50 grades. Fig. 2 shows a general decrease in relative consumption with increasing viscosity. The data at 60 hp shows an unexplained hump in the curve between 4 and 6 centistokes. The difference between the relative consumptions shown for the reference oil and the test oil at the same viscosity is probably due to the volatility of the lighter neutral used in compounding the test oils. The viscosity increase data for these tests showed higher viscosity increases for the more viscous oils.

The effect of three viscosity index improvers on oil consumption was compared with the effect of residual stocks. These materials were blended with relatively non-volatile neutral to the same viscosity at 350F. Therefore, if consumption can be predicted from viscosity at 350F, the consumption for all five oils would be the same. Oils VI-1 and VI-2 in Fig. 3 were blended with two different residual stocks and provide Newtonian type baselines for comparing the viscosity index improver containing oils. Oil VI-3 contained 12.5 per cent of viscosity index improver R-2. Oil VI-4 included 7 per cent of improver S while VI-5 contained 25 per cent of viscosity index improver T. Oils VI-3 and 4 exhibited higher oil consumption rates than the other oils, probably due to temporary and/or permanent shear of the viscosity index improvers. VI-5 did not demonstrate this increased rate of consumption. A significant degree of permanent shear occurred with all of the viscosity index improver containing oils.

The consumption of an SAE 10W-30 oil was compared to that of an SAE 20. In laboratory tests at low levels of consumption the 10W-30 oil was consumed at a rate greater than the 20 oil. At higher levels of consumption both oils were consumed at the same rate. Three different road tests in trucks and passenger cars substantiated this varying relationship between these two oils. ★

Car's Exhaust System Traps Lead in Light City Driving

Lead exhausted into the air in city driving is only a light portion of the total lead in the gasoline burned, according to a paper presented by an Ethyl Corporation engineer at the Atlantic City, New Jersey, ACS meeting.

Under the light loads of city driving, the exhaust system acts as a trap for up to 80 per cent of the lead burned. Extended city driving builds up the deposits to such an extent that the ultimate lead expelled is about 30 to 60 per cent of consumption.

Speeds found in country driving "burn off" the deposits accumulated in the city. At 60 mph, the lead exhausted was as much as 250 per cent of consumption while full acceleration brought the exhausted lead up to as 1990 per cent.

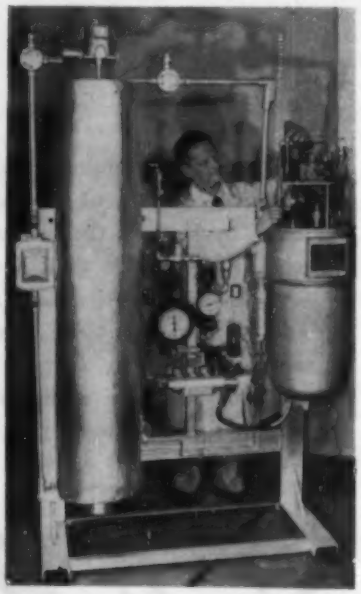
It was reported, happily, that no trouble has been reported from lead exhausted from automobiles in city driving. Analyses of air in many cities in recent years have shown that lead concentrations are so low as to be insignificant as judged by hygenic criteria.

Octane Numbers Climb

Octane numbers go continuously upward, according to du Pont's quarterly survey of the rating of motor fuels being sold throughout the country in 54 consuming centers of the nation. The survey tested 784 fuels in October to arrive at its decision.

The lowest premium fuel rating was in Edmonton, Alberta, 92.3 Research; the result in Calgary, Alberta, was 92.6 average. The highest premium rating was in Houston, Texas, in a heavy refining area, 98.0 Research, at sealevel, and not an area where car requirements are at a premium. Highest tetraethyllead amounts used was in Bakersfield, California, where the average TEL content was 2.93 cc per gal, close to the legal limit, 3.0 cc per gal.

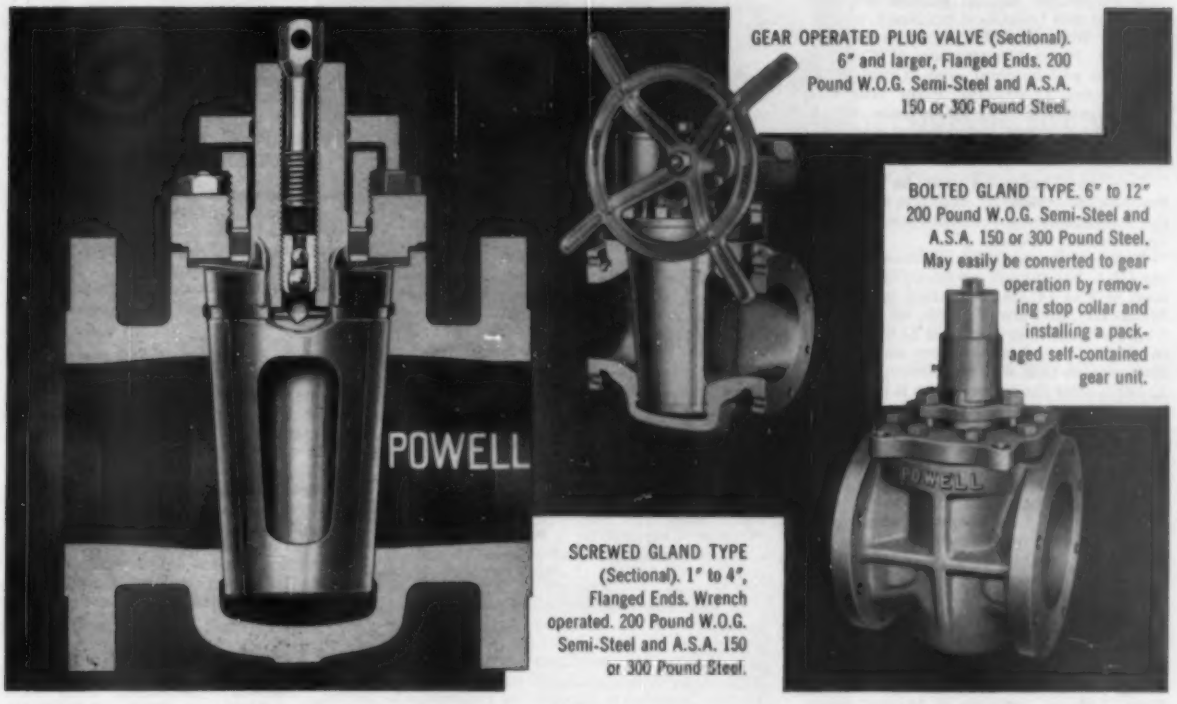
Among regular "housebrand" motor fuels 2.77 cc of TEL per gal was the highest average, at Baltimore, Maryland, 92.2 octane number was the highest, in Pittsburgh, Pennsylvania, lowest average value was 83.1 Research, not surprising since Salt Lake City is in the heart of the mountain marketing area. Consistency and a relatively narrow spread is the general rule throughout the country, but the upward trend is still unmistakable.



"Grass to gas" — Inventor Charles W. Skarstrom of the Esso Research and Engineering Company is shown with chromatograph he tailored for use automatically analyzing gases in oil refining. Fifty years ago, chromatography was invented by a University of Warsaw lecturer as a laboratory technique for studying what makes grass and plant life green.

POWELL

Lubricated Plug VALVES



GEAR OPERATED PLUG VALVE (Sectional). 6" and larger, Flanged Ends. 200 Pound W.O.G. Semi-Steel and A.S.A. 150 or 300 Pound Steel.

BOLTED GLAND TYPE. 6" to 12" 200 Pound W.O.G. Semi-Steel and A.S.A. 150 or 300 Pound Steel. May easily be converted to gear operation by removing stop collar and installing a packaged self-contained gear unit.

SCREWED GLAND TYPE (Sectional). 1" to 4", Flanged Ends. Wrench operated. 200 Pound W.O.G. Semi-Steel and A.S.A. 150 or 300 Pound Steel.

Powell Lubricated Plug Valves maintain our 110-year tradition of quality and precision. Only the finest available materials are used. And painstaking quality control is rigidly enforced through each and every step of manufacture.

Features include quick and positive operation—just a quarter-turn to open or close. Lubricant grooves surrounding each port provide a positive seal when the valve is closed. In an open position, seating surfaces are not exposed.

Valve users who want one source of supply for lubricated plug as well as all types of bronze, iron, steel and corrosion-resistant valves will want full details on Powell Lubricated Plug Valves.

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REFINERY PLANTS SCHEDULED FOR COMPLETION

A new 7000 bbl per day refinery is being built near Gallup, New Mexico, by Southwestern Engineering Company, for El Paso Natural Gas Products Company; owners plan to just about double this capacity, eventually. Will be completed by October, 1957, with Platformer, fluid cat cracker, and HF alkylation unit.

A 25,200 bbl per day residuum stripper is being built for Standard Oil of California at El Segundo, to provide distillate for charging to a fluid cat unit, and heavy residuum for fuel oils. Fluor Corporation, Los Angeles, is constructor, cost estimate is about $3,000,000, and is to be completed by April, 1957.

A 30,000,000 annual pounds alkylate detergent unit (duodecyl benzene), will be built for Imperial Oil Ltd. at Sarnia, Ontario, by Fluor Corporation of Canada, Ltd., and will be completed in mid-1957. It will cost $3,800,000. Plant also will make tripropylene, tetraphopylene, which will make Canada independent for supplies of this detergent ingredient.

Two new refineries will be built in Panama, according to contracts signed by the Panamanian government and two independent companies.

Refineria Panama S.A. (Panama Refining Co.), has bought about 2000 acres of land in Las Minas, extending up to Las Minas Bay, and also Payardi, off the coast where a deep water dock will be built.. Size of the refinery has not been announced, and construction will start about January 1, 1957, after the rainy season is past. This company's president is D. K. Ludwig.

Refineria Y Petroquimica S. A. (Panama Refinery and Petrochemical Company), is headed by J. H. Shaheen, has not announced choice of a site, or plant capacity. Neither plant can be built in Colon, Panama City, nor in the Canal Free Zone. Refining must start not later than August 6, 1960. The U. S. Embassy at Panama City may be a source of further information.

An 80,000 bbl per day crude unit is being built at Shell Petroleum's Shell Haven refinery in England and it is to be completed by late 1958. E. B. Badger & Sons, Ltd., is building it to cost some $18,200,000.

A 50,000 annual-ton hydrogenation unit is being constructed at Odessa, Texas, for Odessa Butadiene Company, to make butadiene from normal butane for the synthetic rubber plant is going in at that location. Fluor Corporation, Ltd., are builders, to be completed by July, 1957.

A 25,000 bbl per day atmospheric-vacuum distillation unit (especially to make asphalts) will be built at the new American Oil Company, Yorktown, Virginia, refinery soon to be on stream. Company expects to market the first Virginia-made gasoline in November. American Oil now makes asphalt at Texas City, at Savannah, Georgia, and Baltimore, Maryland, and will acquire more capacity when a planned merger with Pan Am Southern Corporation is realized, at that company's Detrehan, Louisiana, plant.

A 12,000 bbl per day Sovaformer unit will be built for General Petroleum Corporation soon; scheduled for Torrance, California, refinery, it is to be complete by October, 1957. Builder is not announced.

A natural gasoline products plant will be built by Sunray Mid-Continent Oil Company in the vicinity of East Victor field, near Carney, Lincoln County, Oklahoma, to process 17,500,000 cu ft of raw gas from that field. Dry gas will be returned to Cities Service Gas Company after processing. Jernigan & Morgan Pipe Line Company and McRae Oil & Gas Company Lines will collect the field gas. Tuloma Builders of Tulsa will build the plant, operation of which is planned for April 1, 1957.

A 6000 bbl per day Ultraformer is to be built at Standard Oil of Indiana's Neodesha, Kansas, refinery. Construction is to start early next year and the plant to be on stream by January, 1958. Foster Wheeler Corporation is builder, and the unit will include a naphtha desulfurization unit to prevent the charge stock.

A fluid coker unit of 4000 bbl per day capacity will be built by Bankline Oil Company, at its Bakersfield, California, refinery, to be completed in December, 1956. Unit is designed and engineered by Fluor Corporation, licensed by Esso Engineering and Research Company.

A 1000 bbl per day lubricating oil unit, to operate on naphthene-base crude fractions, and a lubricating grease plant will be started building soon, at Salamanca, Mexico, by the government monopoly Petroleos Mexicanos. Both units are to be completed in 1958. Cost will be about $4,500,000; a paraffin-base lube unit already is operating at Salamanca.

Five Powerformer units are building or have been built recently for Imperial Oil, Ltd., a 4000 bbl per day at Ioco, British Columbia; a 9000 bbl per day at Montreal East, Quebec; a 13,500 bbl per day at Sarnia, Ontario; a 6300 bbl per day at Halifax, Nova Scotia; and a 2200 bbl per day at Edmonton, Alberta.

A 21,000,000 annual gal of aromatics extraction capacity will be built by Ashland Oil & Refining Company at its Buffalo, New York, Frontier Refining Division. A new 7500 bbl per day cat reformer will supply the aromatics-carrying distillate; xylenes, toluene and benzene as well as other aromatics will be recovered.

Synthetic methanol capacity at Sterlington, Louisiana, will be increased "substantially" by addition of a unit using Badger Manufacturing Company's new process for making extra-high purity methanol (wood alcohol). Badger is building the new unit, scheduled for completion by mid-1957.

Petrochemical and alkylate units will be built for Imperial Oil, Ltd., at Sarnia. Canadian Bechtel, Ltd., will build the $25,000,000 petrochemical plant; Fluor Corporation of Canada will build the detergent alkylate plant.

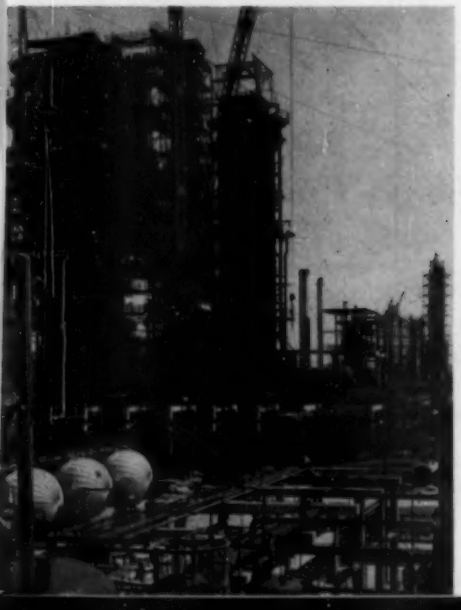
A new natural gasoline plant is to be built by Texas Natural Gasoline Corporation near Baker, Montana, to make propane, butane and natural gasoline and to strip natural gas for delivery to Montana-Dakota Utilities Company. Company already has one plant in the area at Cut Bank, Montana.

An Ultraforming (catalytic reforming) unit is to be built for Standard Oil Company (Indiana), beginning early next year; is to be operating by the first of 1958. Foster Wheeler Corporation will build it.

Modernization of Continental Oil Company's Denver, Colorado, refinery, now of 11,000 bbl per day capacity, will be started soon. Plans include a 3,300 bbl per day catalytic reforming unit (process not announced). Bids from contractors have been invited. Overall cost about $1,400,000, work to be completed by January 1, 1958.

New gas processing plant — A 100,000,000 cu ft per day processing plant to be built for Aluminum Company, by the Construction Division, ALCO of America, at Point Comfort, Calhoun County, Texas. Engineered by Prengle, Dukler & Crump, consulting engineers, Houston, Texas, the plant is to be completed by spring, 1957.

A $500,000 gasoline plant is to be built for Akron Gasoline Company at Akron, Colorado, engineered by Prengle, Dukler & Crump, consulting engineers. It is to be completed by November, 1956, work to be done by the company's own staff.



Tidewater Oil's Plant Looming. Scheduled to begin operations late this year, the Tidewater Oil Company's new 130,000 B/D Delaware Flying A Refinery, under construction south of Wilmington, boasts an ever-growing skyline, which already has become a Delaware landmark. Tall vessels in the background are part of the Orthoflow fluid catalytic cracker, the furthest advanced of the plant's major processing units and the world's largest, with a daily capacity of 102,000 bbl.

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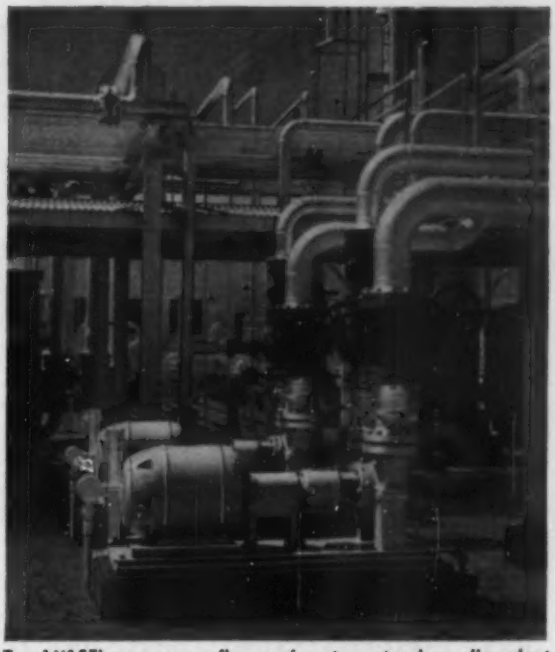
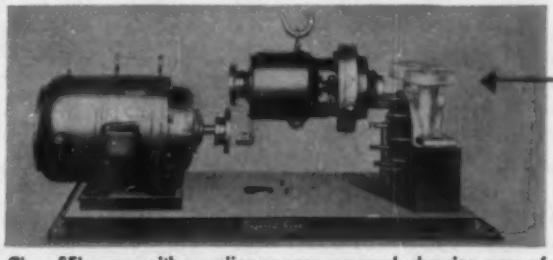
IMPELLER is carefully balanced for freedom from vibration. Made of bronze, iron or steel, for maximum service life under operating conditions. Impeller attached to shaft with pin-locked cap screw—can't work loose.

CASING is heavy-walled to provide corrosion allowance with conservative safety factor at maximum working pressure. Centerline support and water cooled stuffing box for hot liquid service to 800°F.

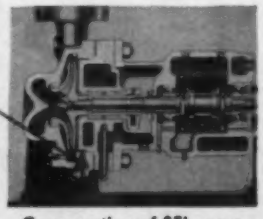
CASING LOCATING PIN, centered under casing, assures perfect pump alignment during high-temperature operation.



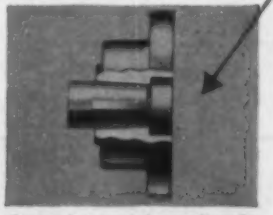
Two 1½" SFL pumps on reflux service at a natural gasoline plant.



Class SFL pump with coupling spacer removed, showing ease of disassembling pump unit.



Cross section of SFL pump



Ground, tapered coupling fit

SHAFT, of heat-treated carbon steel or stainless-steel, is fully ground and polished—held to close tolerances over entire length for perfect fit of replacement parts.

STUFFING BOX is deep enough to allow packing to be arranged to suit the application. Holds 8-10 rings, packed solid. Mechanical Shaft Seals can also be supplied.

SPLIT-TYPE GLAND is easy to remove from shaft. Smothering liquid can be circulated through gland when hazardous liquids are handled.

SPACER COUPLING permits quick, easy removal of entire pumping assembly without disturbing piping or driver.

TAPERED COUPLING FIT, with key and lock nut, eliminates need for shrink fit and permits easy removal or replacement.

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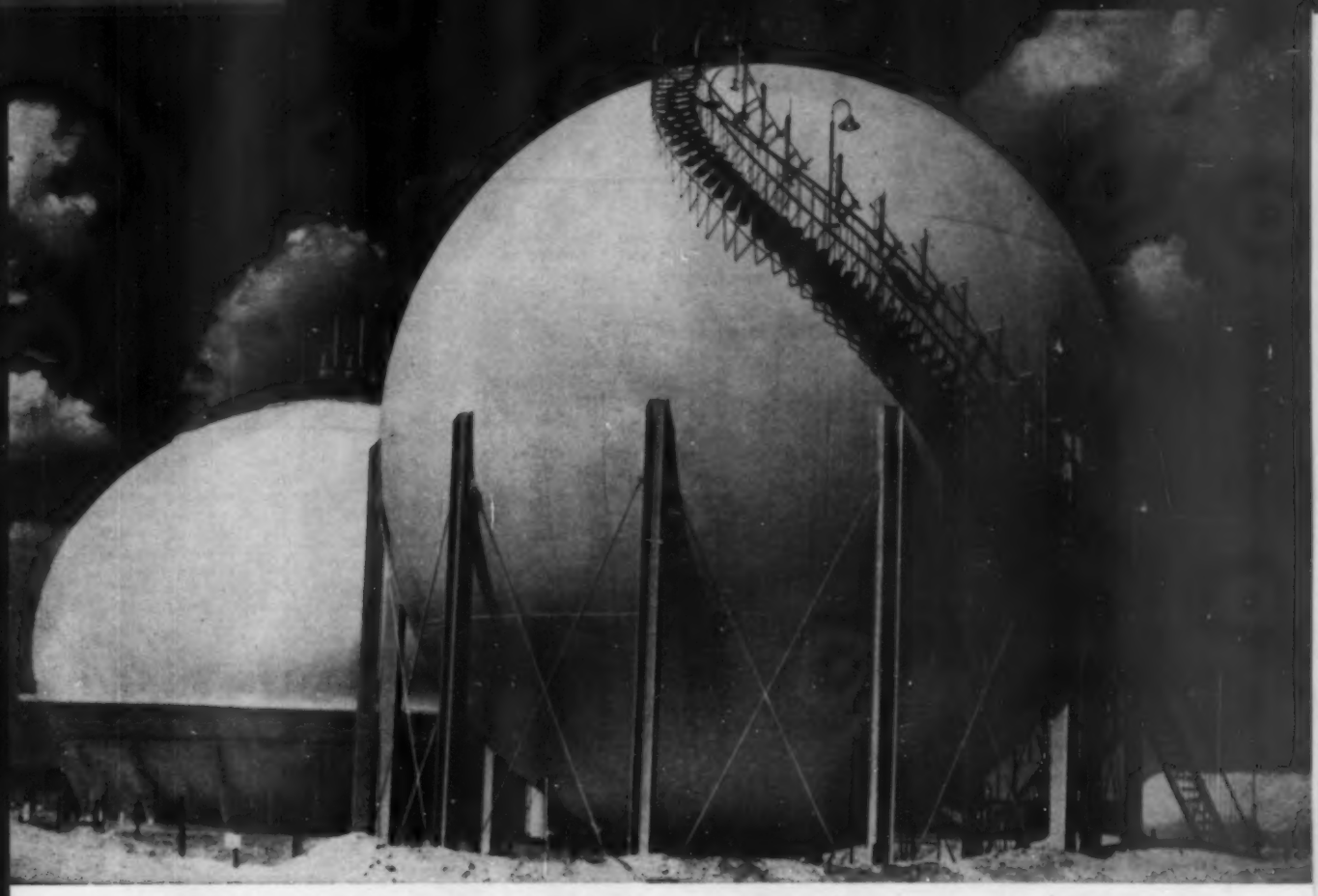
CONVERSION OF TETRAETHYL LEAD IN ISOOCTANE TO OCTANE NUMBER

$$\text{Octane Number} = 100 + \frac{\text{Performance No.} - 100}{3}$$

ML TEL Per Gallon Isooctane	OCTANE NUMBER										ML TEL Per Gallon Isooctane
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	
0.0	100.0	100.1	100.3	100.4	100.5	100.7	100.8	100.9	101.1	101.2	0.0
0.1	101.3	101.4	101.6	101.7	101.8	101.9	102.0	102.1	102.3	102.4	0.1
0.2	102.5	102.6	102.7	102.8	102.9	103.0	103.1	103.2	103.3	103.4	0.2
0.3	103.5	103.6	103.7	103.8	103.9	104.0	104.1	104.2	104.3	104.3	0.3
0.4	104.4	104.5	104.6	104.7	104.8	104.9	104.9	105.0	105.1	105.2	0.4
0.5	105.3	105.4	105.4	105.5	105.6	105.7	105.7	105.8	105.9	106.0	0.5
0.6	106.0	106.1	106.2	106.3	106.3	106.4	106.5	106.5	106.6	106.7	0.6
0.7	106.7	106.8	106.9	106.9	107.0	107.1	107.1	107.2	107.3	107.3	0.7
0.8	107.4	107.5	107.5	107.6	107.6	107.7	107.8	107.8	107.9	108.0	0.8
0.9	108.0	108.1	108.1	108.2	108.2	108.3	108.4	108.4	108.5	108.5	0.9
1.0	108.6	108.6	108.7	108.7	108.8	108.8	108.9	109.0	109.0	109.1	1.0
1.1	109.1	109.2	109.2	109.3	109.3	109.4	109.4	109.5	109.5	109.6	1.1
1.2	109.6	109.7	109.7	109.8	109.8	109.9	109.9	109.9	110.0	110.0	1.2
1.3	110.1	110.1	110.2	110.2	110.3	110.3	110.4	110.4	110.4	110.5	1.3
1.4	110.5	110.6	110.6	110.7	110.7	110.7	110.8	110.8	110.9	110.9	1.4
1.5	111.0	111.0	111.0	111.1	111.1	111.2	111.2	111.2	111.3	111.3	1.5
1.6	111.4	111.4	111.4	111.5	111.5	111.5	111.6	111.6	111.7	111.7	1.6
1.7	111.7	111.8	111.8	111.9	111.9	111.9	112.0	112.0	112.0	112.1	1.7
1.8	112.1	112.1	112.2	112.2	112.2	112.3	112.3	112.4	112.4	112.4	1.8
1.9	112.5	112.5	112.5	112.6	112.6	112.6	112.7	112.7	112.7	112.8	1.9
2.0	112.8	112.8	112.9	112.9	112.9	113.0	113.0	113.0	113.0	113.1	2.0
2.1	113.1	113.1	113.2	113.2	113.2	113.3	113.3	113.3	113.4	113.4	2.1
2.2	113.4	113.5	113.5	113.5	113.5	113.6	113.6	113.6	113.7	113.7	2.2
2.3	113.7	113.7	113.8	113.8	113.8	113.9	113.9	113.9	113.9	114.0	2.3
2.4	114.0	114.0	114.1	114.1	114.1	114.1	114.2	114.2	114.2	114.3	2.4
2.5	114.3	114.3	114.3	114.4	114.4	114.4	114.4	114.5	114.5	114.5	2.5
2.6	114.5	114.6	114.6	114.6	114.6	114.7	114.7	114.7	114.7	114.8	2.6
2.7	114.8	114.8	114.9	114.9	114.9	114.9	114.9	115.0	115.0	115.0	2.7
2.8	115.0	115.1	115.1	115.1	115.1	115.2	115.2	115.2	115.2	115.3	2.8
2.9	115.3	115.3	115.3	115.4	115.4	115.4	115.4	115.5	115.5	115.5	2.9
3.0	115.5	115.5	115.6	115.6	115.6	115.6	115.7	115.7	115.7	115.7	3.0
3.1	115.7	115.8	115.8	115.8	115.8	115.9	115.9	115.9	115.9	115.9	3.1
3.2	116.0	116.0	116.0	116.0	116.1	116.1	116.1	116.1	116.1	116.2	3.2
3.3	116.2	116.2	116.2	116.2	116.3	116.3	116.3	116.3	116.3	116.4	3.3
3.4	116.4	116.4	116.4	116.4	116.5	116.5	116.5	116.5	116.5	116.6	3.4
3.5	116.6	116.6	116.6	116.6	116.7	116.7	116.7	116.7	116.7	116.8	3.5
3.6	116.8	116.8	116.8	116.8	116.9	116.9	116.9	116.9	116.9	117.0	3.6
3.7	117.0	117.0	117.0	117.0	117.0	117.1	117.1	117.1	117.1	117.1	3.7
3.8	117.2	117.2	117.2	117.2	117.2	117.2	117.3	117.3	117.3	117.3	3.8
3.9	117.3	117.4	117.4	117.4	117.4	117.4	117.4	117.5	117.5	117.5	3.9
4.0	117.5	117.5	117.5	117.6	117.6	117.6	117.6	117.6	117.7	117.7	4.0
4.1	117.7	117.7	117.7	117.7	117.8	117.8	117.8	117.8	117.8	117.8	4.1
4.2	117.9	117.9	117.9	117.9	117.9	117.9	118.0	118.0	118.0	118.0	4.2
4.3	118.0	118.0	118.0	118.1	118.1	118.1	118.1	118.1	118.1	118.2	4.3
4.4	118.2	118.2	118.2	118.2	118.2	118.3	118.3	118.3	118.3	118.3	4.4
4.5	118.3	118.4	118.4	118.4	118.4	118.4	118.4	118.4	118.5	118.5	4.5
4.6	118.5	118.5	118.5	118.5	118.5	118.6	118.6	118.6	118.6	118.6	4.6
4.7	118.6	118.7	118.7	118.7	118.7	118.7	118.7	118.7	118.8	118.8	4.7
4.8	118.8	118.8	118.8	118.8	118.8	118.9	118.9	118.9	118.9	118.9	4.8
4.9	118.9	118.9	119.0	119.0	119.0	119.0	119.0	119.0	119.0	119.1	4.9
5.0	119.1	119.1	119.1	119.1	119.1	119.1	119.2	119.2	119.2	119.2	5.0
5.1	119.2	119.2	119.2	119.2	119.3	119.3	119.3	119.3	119.3	119.3	5.1
5.2	119.3	119.4	119.4	119.4	119.4	119.4	119.4	119.4	119.4	119.5	5.2
5.3	119.5	119.5	119.5	119.5	119.5	119.5	119.6	119.6	119.6	119.6	5.3
5.4	119.6	119.6	119.6	119.6	119.7	119.7	119.7	119.7	119.7	119.7	5.4
5.5	119.7	119.7	119.8	119.8	119.8	119.8	119.8	119.8	119.8	119.8	5.5
5.6	119.9	119.9	119.9	119.9	119.9	119.9	119.9	119.9	120.0	120.0	5.6
5.7	120.0	120.0	120.0	120.0	120.0	120.0	120.1	120.1	120.1	120.1	5.7
5.8	120.1	120.1	120.1	120.1	120.1	120.2	120.2	120.2	120.2	120.2	5.8
5.9	120.2	120.2	120.2	120.3	120.3	120.3	120.3	120.3	120.3	120.3	5.9
6.0	120.3										6.0

Courtesy of the Petroleum Chemicals Division of E. I. duPont de Nemours & Company (Inc.)

CUT ALONG THIS LINE FOR YOUR PERSONAL REFERENCE FILE.



Cut evaporation losses with DULUX® Tank White Enamel

Today, major oil companies have found a way to give their huge oil-storage investments top protection against evaporation—at top economy—by painting tanks with DULUX Tank White Enamel.

REFLECTS THE SUN'S HEAT. Petroleum experts agree that painting a tank white results in heat reflectance that sharply reduces costly evaporation losses. Many users report evaporation cut close to 85% on tanks painted with DULUX Tank White. Titanium dioxide, the whitest pigment ever employed in paint, is used for maximum reflectance. And the controlled chalking of the DULUX finish prolongs this exceptional brightness. Tanks actually clean themselves.

APPLICATION SAVINGS. You save the time and expense of a two-scaffold setup when you paint with DULUX Tank White. The second coat of paint can be sprayed on immediately at right angles to the first—a single operation. DULUX applies fast, dries fast.

MAINTENANCE SAVINGS. Painting cycles are extended for years with DULUX Tank White. The rugged DULUX resin base ensures exceptional resistance to corrosion, industrial gases, and rough weather.

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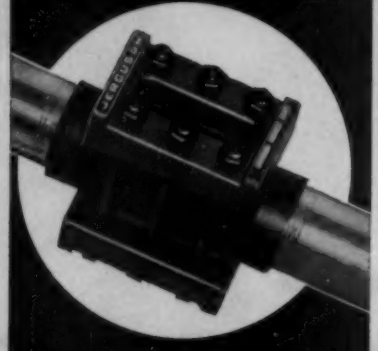
NEW . . .
Jerguson Sight Flow Indicators



easily and inexpensively installed to show movement of liquid in pipe lines

Here is a new line of Sight Flow Indicators . . . easily and inexpensively installed in any new or existing pipe line ½" to 2" N.P.T.

The special design of these new indicators results in a turbulence in the flow of liquid, making it easily visible. Several types of indicating vanes, installed within the chamber, may also be furnished, according to variable conditions of rate of flow and viscosity of liquid. For indication of minute flows, small Sight Flow Indicators with a rotating vertical rising ball are available.

Jerguson Sight Flow Indicators are soundly designed, carefully made, and are backed up by a company with over 40 years experience in the field. Available in Transparent and Reflex types, in a wide variety of materials and linings, and with Wedge Type Illuminators, Haveg Chambers, Non-Frosting Glasses, or other special construction.

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REFINING AND PETROCHEMICAL PERSONALS

D. M. Krausse

▸ **Dan M. Krausse,** formerly manager of manufacturing, has been promoted to vice president in charge of manufacturing for Cosden Petroleum Corporation, Big Spring, Texas. **I. T. King** has been advanced to the position of treasurer. He was formerly assistant treasurer. **A. V. Karcher,** former secretary-treasurer, will devote full time serving as secretary.

▸ **O. V. Tracy** has been elected vice president of Esso Standard Oil Company. Tracy will continue to serve as a member of Esso Standard's board of directors, a post he has held since January, 1954.

J. F. Daley

O. V. Tracy

▸ **John F. Daley** has been promoted from general manager of the organic chemicals department to vice president, director and member of the executive committee of the E. I. du Pont de Nemours & Company.

Samuel G. Baker, formerly general manager of the photo-products department, has been named to succeed Daley.

▸ **Dr. Heinz Heinemann** has been elected president of the newly organized International Congress of Catalysis, and Dr. Heinemann and **Dr. Alex G. Oblad** have been re-elected to the board of directors. Both men are with the Houdry Process Corporation.

Heinemann was born in Berlin, Germany, and is author of numerous publications and patents on catalytic and petroleum chemistry. He has worked for several petroleum companies and catalyst manufacturers before joining Houdry.

Oblad, vice president and member of the board of directors of Houdry, is chairman of the petroleum chemical division of the American Chemical Society.

▸ Eight new supervisors have been appointed at Tidewater Oil Company's new Delaware Flying A Refinery. The new supervisors, and the posts they will hold, are: **Eugene Andrechak,** supervisor of economic planning; **Leo T. Briggs,** supervisor of stores; **Charles W. Christie,** supervisor of accounting; **Russell J. Hawes,** supervisor of refinery technology; **Leslie C. Johns,** fire chief; **Harry Sharkey,** assistant supervisor of accounting; **Vincent J. Tkac,** supervisor of control laboratories, and **Adam J. Transou,** supervisor of inspection.

▸ **Walter S. Svenson** has been appointed manager, process development, of the California Oil Company. Svenson succeeds **E. E. Gullekson,** who has been transferred to San Francisco.

M. A. Ellsworth

▸ **M. A. Ellsworth,** vice president and general manager, engineering and construction division, The Fluor Corporation, Ltd., has been named to Fluor's board of directors.

Ellsworth joined the Fluor sales staff in 1940, advancing to vice president of sales in 1952. Last year he became vice president and general manager, engineering and construction division.

▸ **Dr. Adalbert Farkas,** section chief in exploratory research at Houdry Process Corporation, has been elected to the board of directors of the newly-organized International Congress on Catalysis.

▸ **Dr. John W. Bishop,** a research group leader in Tidewater Oil Company's eastern division, has been transferred to the company's national organization headquarters in San Francisco, California.

ERNST
Boiler Accessories

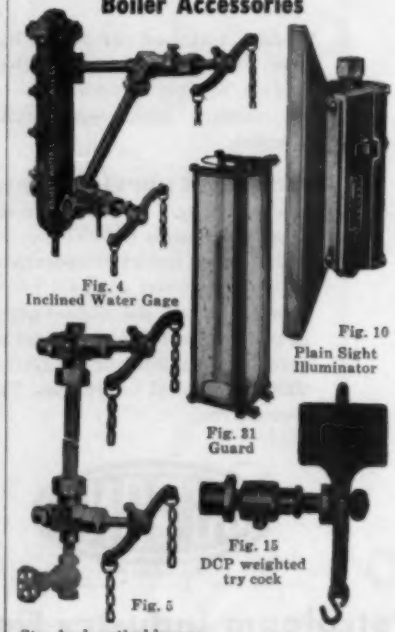

Fig. 4 Inclined Water Gage
Fig. 10 Plain Sight Illuminator
Fig. 31 Guard
Fig. 15 DCP weighted try cock
Fig. 5 Standard vertical bronze water gage, 350 pound

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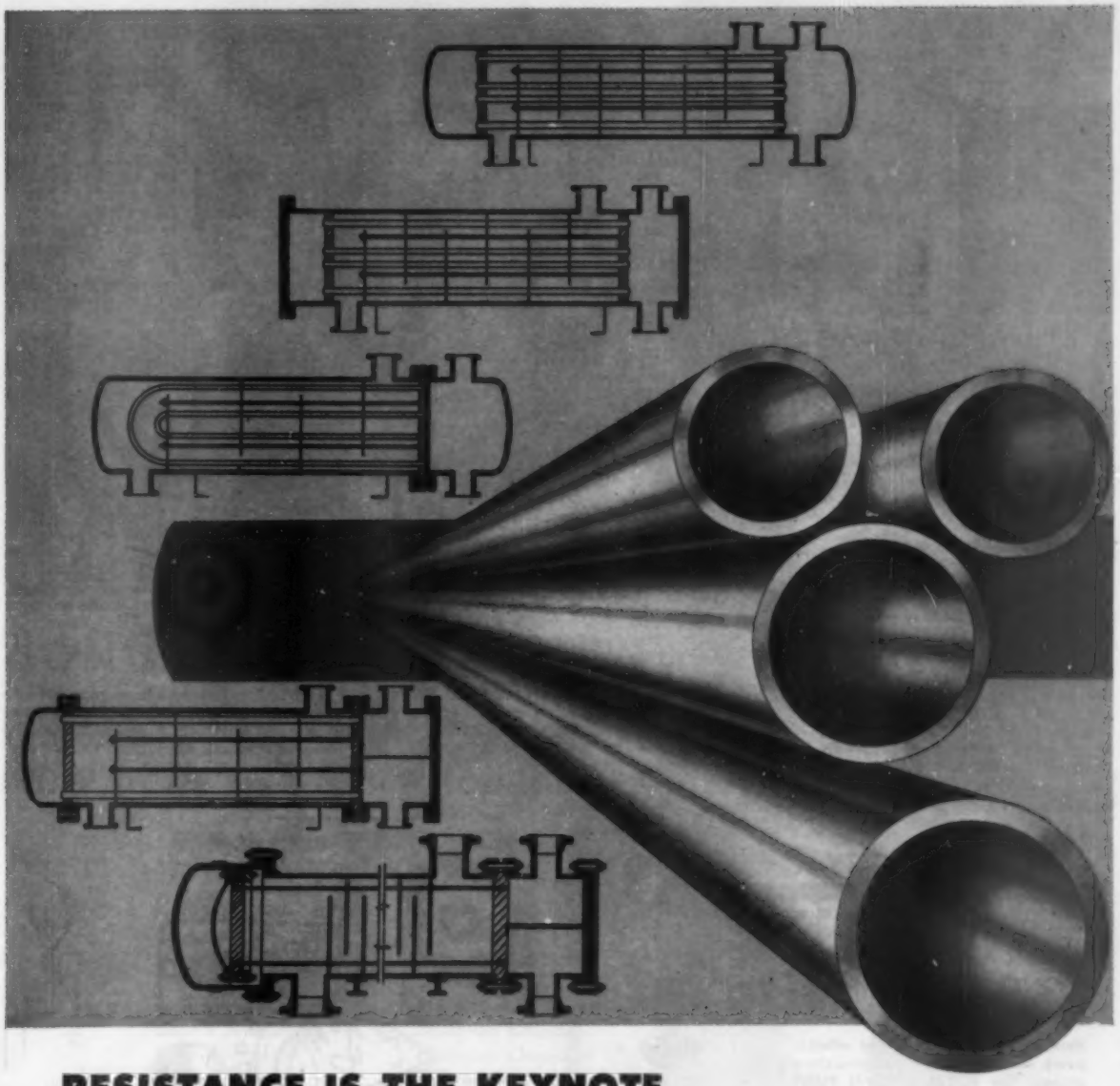
Livingston, N. J.



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Resistance to corrosion and contamination of product is the job of B&W Condenser and Heat Exchanger Tubes in the process industries. In myriad processes where resistance to these factors is a major consideration, selection of the best tube steel analysis for optimum performance is of paramount importance in any application.

B&W offers a wide variety of grades, seamless or welded, to meet virtually every requirement, economically and dependably. In addition to designers' preferences, shop men like B&W Tubing because they know from experience that B&W Tubes are easy to bend, to roll in, and to weld.

B&W Condenser and Heat Exchanger Tubes are included in the comprehensive warehouse stocks of many helpful, well-informed independent B&W tubing distributors. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pa.

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FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Personals

▸ **H. C. Lyles** has been promoted to general foreman of utilities department at Humble Oil & Refining Company's Baytown, Texas, refinery.

H. C. Lyles

P. C. Folse

▸ **Parker C. Folse,** safety director of Magnolia Petroleum Company's refining division, Beaumont, Texas, has been selected by Socony Mobil Oil Company, Inc., to assist in directing that firm's world-wide accident and fire prevention efforts and will be headquartered in New York City.

▸ **John J. McDonald,** assistant director of the systems division, Consolidated Electrodynamics Corporation, has been appointed director of the newly created transportation industry division of the Instrument Society of America.

▸ **Dr. Lauren B. Hitchcock** has announced that he will resign as president and managing director of the Air Pollution Foundation in November to return to private practice as a management consultant in industrial research and development.

▸ Several promotions affecting aviation and technical personnel have been announced by Esso Export Corporation.

A. R. Ogston becomes technical consultant, a newly authorized corporate staff position. **E. O. Petzold** has been promoted to head the technical service division of Esso Export's aviation department succeeding Ogston. **J. P. Acton** has been appointed head of the field service division of Export's aviation department.

▸ **Dr. Carroll A. Hochwalt,** vice president for research, development and engineering of the Monsanto Chemical Company, has been named winner of the 1956 Midwest Award of the American Chemical Society's St. Louis section.

▸ **Dr. William A. Pardee** of the Gulf Research and Development Company, has been awarded the Scroll of Honor of the American Chemical Society's division of industrial and engineering chemistry.

▸ Humble Oil & Refining Company announces the following staff additions at its Baytown, Texas, refinery: **H. C. Edwards,** MS in mathematics; **L. P. Karvelas,** MBA; **J. M. Montgomery,** BS in chemical engineering; and **H. B. Payne,** BS in chemical engineering. In research and development division, **E. M. Magee,** PhD in physical chemistry; **W. A. Morgan,** BS in mechanical engineering; **R. E. Pennington,** PhD in chemical engineering; **J. T. Richardson,** PhD in physics; and **D. H. Willson,** MS is organic chemistry.

J. O. Allred, B. A. Martin, and **W. N. Lyster** have recently returned to technical service division from military service. Each holds a BS degree in chemical engineering.

W. C. Soudriette

▸ **William C. Soudriette,** Bartlesville, Oklahoma, has been appointed plant manager for Cities Service Oil Company's large East Chicago, Indiana, refinery. He succeeds **L. E. Taylor,** who is to be chief engineer of Petroleum Chemicals, Inc., in which Cities Service holds a substantial interest.

Also announced were two assistant managers for the East Chicago refinery —

J. A. Witherspoon

E. E. Johnson

John A. Witherspoon, assistant manager in charge of operations, and **Elmore E. Johnson** as assistant manager in charge of personnel.

▸ **T. M. Newsom** has been promoted to senior chemical engineer and **C. L. Thorpe** to senior research chemist in technical and research divisions at Humble Oil & Refining Company's Baytown, Texas, refinery.

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Here's the simplest and most efficient pump valve made for reciprocating pumps. The ROYAL CROWN PUMP VALVE has only three separate parts, yet its performance is revolutionary! Valve is guided by a frictionless ball stem which allows it to oscillate and turn with the fluid stream. Swings completely free with each stroke of the pump . . . seating each time in a new position. Resistance to fluid is reduced to a minimum which means greater pump volume at less pump speed. Adaptable to all reciprocating pumps . . . handles all types of liquids.

Royal Crown PUMP VALVES

(A) Round valve surface is streamlined. No obstructions to restrict the flow. (B) Ball-guided valve rotates and swings with each stroke of the pump. Each turn, each swing . . . a lapping action, a continuing perfect seat. (C) Free vertical action assures instant opening and closing. Ball stem is a frictionless guide.

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Here are many more production-controlled, high-quality fluorides:

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Frosting Mixtures
Hydrofluoric Acid Anhydrous
Hydrofluoric Acid Aqueous
Hydrofluosilicic Acid
Lead Fluoborate
Metallic Fluoborates
Potassium Bifluoride
Potassium Chromium Fluoride
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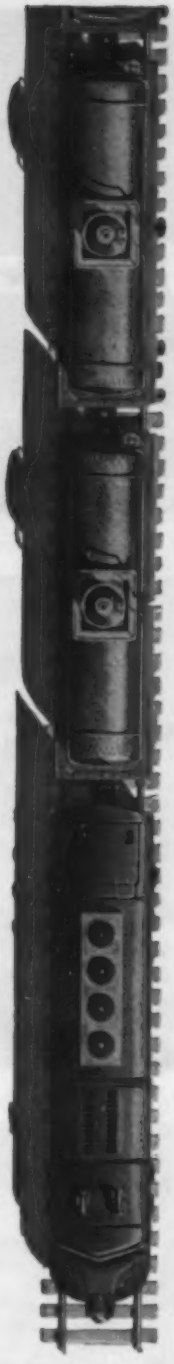
Potassium Titanium Fluoride
Silico Fluorides
Sodium Fluoborate
Tin Fluoborate
Zinc Fluoborate
Zinc Fluoride



WRITE FOR
Harshaw's 40-page Book on Hydrofluoric Acid Anhydrous. It provides helpful data.

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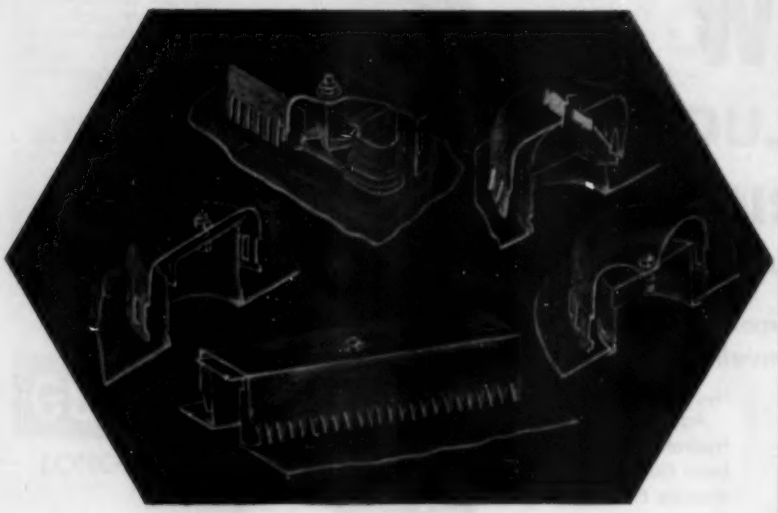
Glitsch



Glitsch Bubble Cap and Riser Assemblies have been the standard of the petroleum and the chemical industries for years. As a result, we have dies for more than 300 different caps and risers for every process requirement. Virtually every conceivable type and design can be furnished, in either round or rectangular assemblies, with a full range of sizes and materials.

Glitsch Caps and Risers have a number of operating features not available in any other equipment. They are easy to install and remove, which reduces downtime for cleaning and allows the unit to be placed back on stream with a minimum shut-down time.

Your nearest Glitsch office will be glad to give you additional details and illustrated technical literature on Glitsch Bubble Caps, "Truss-Type"® Trays, and other Glitsch products and services for the petroleum refining and chemical process industries. There is no obligation, and you will be pleased with the prompt and competent recommendations our representatives will make for your job.

Glitsch

Engineer John Lincoln and his passengers hitched a ride inside a truck van via ferry to make a wedding on time.

Esso Engineer Thinks Fast

Here's how an Esso Standard engineer and a Long Island wedding almost—but not quite—missed the boat.

Process engineer, John Lincoln, of Everett, Massachusetts, was driving two bridesmaids and an usher to the nuptials at Southampton, Long Island. Their route included a short-cut by water, the New London-to-Long Island ferry.

This was much quicker, they sensibly figured, than driving all the way. But they didn't figure on trucks, which have priority over autos on the ferry. Too many were due to pull on ahead of them, leaving no room on the boat for Lincoln's convertible and the wedding party.

Wait 4½ hours for the next boat? Or drive all the way around to Southampton? Either would mean a delayed wedding, or one which proceeded without three of its principals.

An engineer's solution was provided by Engineer Lincoln, with an assist from a friendly truck driver whose tractor-trailer was just ahead in line.

Obtaining permission to double-up, Lincoln maneuvered his car into the partially empty van of the truck.

Truck and car rolled on the ferry—the last vehicle(s) aboard.

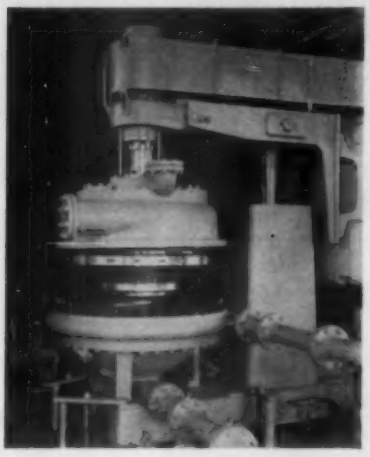
Bridesmaids, usher and their quick-thinking chauffeur all reached Southampton and the wedding on time.

NEW Refining Equipment

• machinery • supplies • services

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

(41) Centrifuge for High Pressure Operations. Dorr-Oliver has announced availability of the Merco Pressure Centrifuge, said to be the first centrifugal separator



developed for continuous operation at elevated pressures and temperatures. Machine is designed for operation in the 100 psi and 300F range. While the major application to date has been in the polyethelene industry, unit is adaptable to any high-pressure, high or low-temperature processing step.

Dorr-Oliver Incorporated.

(42) Non-Freezing Copper Deactivator. Non-freezing copper deactivator formulation which will remain liquid at temperatures of 0F is offered to the petroleum refining industry by Universal Oil Products.

Called UOP Copper Deactivator-AW (50), the formulation contains Universal's regular active ingredient in 50 per cent concentration in solution. It is designed to eliminate the problems of freezing and low-temperature pumping which are characteristic of regular-grade deactivators.

Other characteristics of this UOP formulation are improved color and better solubility, particularly at lowest winter ambient temperatures.

Universal Oil Products Company.

(43) Remote Indicating of Levels. Manufacturing plants and refineries now can be equipped with remote control devices that are claimed to measure the level in storage tanks and bins located more than three quarters of a mile away.

Instrument, called a capacity telemeter, can be connected by coaxial cable to a control position as far as 4000 ft away. Its accuracy in gaging the contents of a tank is unaffected by changes in weather conditions or electrical properties of the cable.

The complete capacity telemeter system consists of a measuring unit, a remote probe unit for each tank, and an indicator which can be a meter, recorder, or precision indicator. Size and shape of tanks using the remote system can be varied with no effect on its accuracy.

Fielden Instrument Division, Robertshaw-Fulton Controls Company.

(44) Diaphragm Control Valve. Black, Sivalls & Bryson has introduced a line of diaphragm control valves, the Super 70 Series, which includes a new topworks, redesigned valve body, and an all-metal float ring seal.

Topworks features a new moulded diaphragm for uniform thrust over full valve travel, pressed steel cases for maximum strength with minimum weight, and a precision-calibrated single spring. Valve bodies are available in three styles — single port, double port, and split body for use in erosive or corrosive fluid service where easy removability of valve seat is desirable.

Black, Sivalls & Bryson, Inc.

(45) Air Compressor Lubricant. A synthetic lubricant for air compressors which minimizes explosions and receiver fires as well as carbon deposits on exhaust valves and air system piping has been announced by Monsanto Chemical's organic chemicals division.

Trademarked Pydraul AC, the lubricant is described by Monsanto as a fire-resistant fluid equivalent in lubricity to a premium-grade lube oil. Quite similar in its properties to the company's other Pydraul fire-resistant fluids, it is reportedly unique in its marked ability to reduce carbon deposition, thus offering important maintenance savings in addition to a wide safety margin in compressed air systems.

Monsanto Chemical Company.

(46) Automatic High-Speed Centrifuge. Engineered with the objective of making high-speed laboratory separations as automatic and routine as possible, the Spinco Model K Centrifuge provides a maximum speed of 25,000 rpm with forces of 50,000 times gravity on 160 ml of material.

Simple in design, Model K is driven with a constant-speed motor, in combination with which a quickly interchangeable

series of pulleys gives a range of 20 speeds from 2500 to 25,000 rpm.

Inclined-tube rotors run in air. Instrument is housed in a single case 36 in. high by 22 in. wide by 32 in. deep.

Spinco Division, Beckman Instruments, Inc.

(47) Proportioning Pump Adaptable to Chemical Feeding. Exceptional feeding accuracy, positive feed-rate setting, and economy of initial and upkeep costs are

features claimed for Model 1140 Proportioneer (chemical proportioning pump) developed by Proportioneers, Inc.

The plug-in reagent end and other standardized mechanical components are readily accessible for easy servicing. This pump also features the Proportioneers Vane-Guide check valves and minimum clearance volume cylinders of self-purging design.

This compact, easily installed unit will handle feed rates from 0.8 gpm to 900 gph and discharge pressures to 1340 psig.

Proportioneers, Inc., division of B-I-F Industries, Inc.

(48) Vaporizer Regulator for Continuous Sample Systems. A vaporizer regulator which is said to assure vaporization and permit pressure control of liquid samples being introduced into analyzers and other petrochemical-monitoring instruments is now available from Consolidated Electrodynamics.

Known as the Type 38-001 Consolidated-Phillips Vaporizer Regulator, it was designed by Phillips Petroleum Company for use with infrared analyzers and refractometers to assure that liquid samples introduced into these and similar instruments would be in the vaporized state and at pressures of about 15 psi. It can be used in continuous sample systems of many analysis instruments, including Consolidated's Process-Monitor Mass Spectrometer.

Consolidated Electrodynamics Corporation.

(49) Porous Metal Filter Elements. Arrow Porous Metal Filter Elements, made of powdered bronze, are designed to filter out harmful solids and contaminants in hydraulic and pneumatic systems.

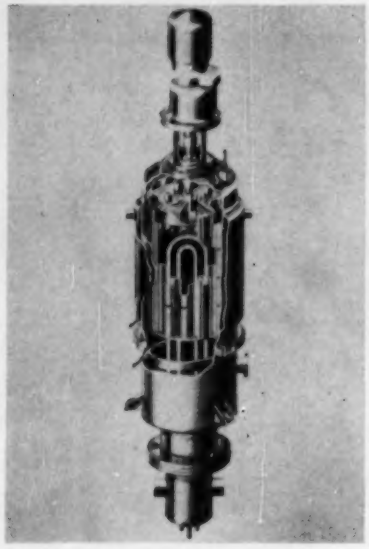
Recent advances in processing methods permit the production of porous bronze filters with maximum filtering area within allowable overall dimensional tolerances.

Design provides largest possible surface filtering area with added depth of filtration and controlled porosity. Filter elements available in grades of particle size removal from 2 microns up to 151 microns.

Arrow Sintered Products Company.

(50) Falling Film Evaporator. A new concept in the design of the falling film evaporator has been marketed by Pfaudler.

In this design, the walls of the still are actually contacted by wipers made of im-



pervious graphite or other suitable materials. Wiper design is unique in that the individual wipers are set at an angle so as to direct the flow downward through evaporator as well as circumferentially. By directing the film downwards to the bottom of the still, extremely short contact times are obtained.

Since the wipers are constructed of short sections, no further compensation for variations in radius are necessary and the need for internal machining is eliminated.

Pfaudler Company.

(51) Precision Teflon Tape. Tri-Point Manufacturing announces the availability of Teflon tape in a wide variety of gages and dimensions.

This fluorocarbon tape, produced in close-tolerance thicknesses, is used in the electronics, aircraft, chemical, and equipment industries as superior high-frequency, high-temperature insulation, chemical gasketting.

Fifteen gages of Tri-Point Teflon tape, from .002 in. to .125 in., are currently available. Tolerance on gage ranges from ± .0005 in. on thin stock, to ± .002 in. on thicker gages. The tape can be specified from stock in widths ranging from ½ in. (suitable for braiding) to 12 in. (wrapping and lining).

Tri-Point Manufacturing, Inc.

(52) Fuel Injection System. An electronic fuel-injection system that is claimed will replace a conventional carburetor on passenger cars, leading to increased power, quicker starting and warm-up periods, plus faster throttle response, has been introduced by Bendix Aviation.

The timed, self-priming system, which provides a wider latitude in fuel characteristics for high-compression engines, is called the "Electrojector." It is now ready to be adapted to engines of any car manufacturer and is said to be the first system to be developed that does not require a special drive off the engine.

Bendix officials point out that the simplified design of the Electrojector means increased power for safety, better fuel economy, quicker starts and warm-up, wider selection of fuels — another economy for the average motorist — more room under the hood, faster and livelier response to the throttle, elimination of vapor locks, and no cornering, or hill-angle effects.

Bendix Aviation Corporation.

(53) Dry-Type Air Filter. A high-efficiency dry-type, renewable media air filter has been developed as the Multi-Pak air filter by American Air Filter.

The Multi-Pak is a dry-type air filter that was developed for those applications that require air filters of standard construction but need higher than normal cleaning efficiencies. Its effectiveness can be regulated by a variety of media, ranging from inexpensive cellulose fiber sheets, through dense, highly effective glass fiber mats.

American Air Filter Company, Inc.

(54) Electron Microscope. A 100-kv electron microscope (Type EM-100B) with many unique operating features, including a hinged objective lens for quick change or cleaning of pole inserts, magnetic compensator, objective diaphragm with multiple apertures, and insert screen with binoculars for ultra-thin specimens, has been announced by the instrument division, North American Philips.

Guaranteed resolving power of the instrument is claimed to be better than 20 Angstrom. High resolution pole pieces permit continuously variable magnification from the control panel through a range of 5000 to 100,000 diam. With diffraction pole pieces, the instrument magnifications are 1750 to 35,000 diam. Camera equipment extends the upper magnificant limit to 200,000. Operating magnification level is indicated directly on a panel meter.

North American Philips Company, Inc.

NEW Literature

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

(55) Chemical Additive Calculator. A convenient, six-scale slide calculator designed to provide accurate and rapid chemical treatment costs and quantity conversions has been prepared by the chemical division of Armour.

Aimed primarily for use by the petroleum industry, the calculator scales have been expanded to be useful to other industries where chemicals are used in parts-per-million treatment rates.

Armour and Company.

(56) Gas Chromatography. A brochure describing its Model 154-B Vapor Fractometer has been published by the Perkin-Elmer's instrument division.

Model 154-B is operable at higher temperatures, has a more sensitive dual thermal-conductivity detector and has, as standard equipment, a solenoid-operated, liquid sample collection outlet.

This 16-page brochure discusses the features and specifications of the new instrument, gives examples of trace analyses possible with it and discusses it's use in conjunction with infrared spectroscopy.

Perkin-Elmer Corporation.

(57) Rubber. A 26-page booklet about Amerinol rubber containing information about its physical properties and processing has been published by Goodrich-Gulf Chemicals.

Booklet contains several charts which analyze the properties of cold non-oil polymers, cold oil-extended polymers, and hot polymers, as well as test recipes and test data.

Goodrich-Gulf Chemicals, Inc.

(58) Cabled Tubes for Instruments and Controls. A 12-page, two-color technical bulletin on cabled tubes for instruments and controls, titled "Crescent Armored Multitube System." has been issued by Crescent Insulated Wire & Cable.

This bulletin gives complete information on various types of Multitube and methods of installation. Illustrations show regular copper and polyethylene tubes, as well as four different corrosion-resistant types.

Crescent Insulated Wire & Cable Company.

(59) Mist Eliminators—Entrainment Separators. Yorkmesh Demisters, for the separation of liquid and vapor-phase materials, are illustrated and described in a bulletin distributed by Otto H. York Company.

Chemical and petroleum applications—to increase throughput capacity, improve process efficiency and overhead quality while reducing contamination and liquid loss—are presented.

Bulletin also provides information on solvent extraction with York-Scheibel liquid-liquid extractors and York line separators.

Otto H. York Company, Inc.

(60) Newsletter. Gardner Laboratory has issued a 16-page product newsletter. Many new instruments are described, including a Ceramic Density Penetrometer, Electric Bunsen Burner, Large-Area Colorimeter.

Gardner Laboratory, Inc.

(61) Convection Heat. A technical paper "Effect of Convection Heat in Radiant Sections of Tubular Process Heaters," by L. A. Mekler, has been published by Petro-Chem Development.

The 12-page paper, with charts and diagrams, fully discusses the heat input by convection heat that is superimposed on radiant rates of tubular process heaters.

In addition, the paper describes a unique series of field tests on several Petrochem-Isoflow heaters under actual operating conditions, using thermocouples and specially designed flue-gas flow meters known as "Velometers."

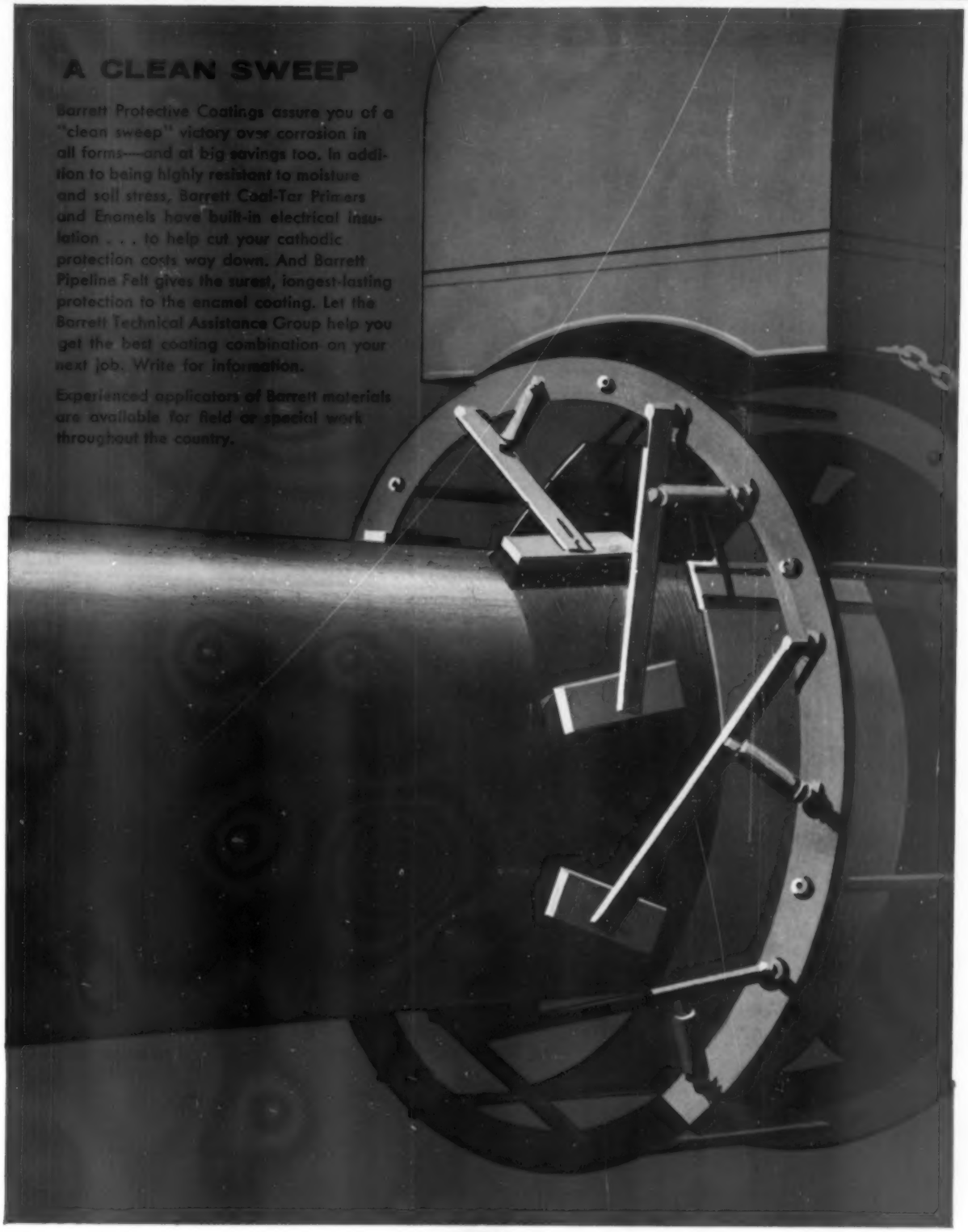
Petro-Chem Development Company, Inc.

CORRECTION

In the article by W. L. Faith, starting on page C-3, October, 1956, *Refining Engineer:*

On page C-6, first column, eleventh line down, the expression "35 gal" should be changed to read "35 per cent."

On the same page, first column, twenty-first line down, the expression "45 gal" should be changed to read "45 per cent." — EDITOR.


A CLEAN SWEEP
Barrett Protective Coatings assure you of a "clean sweep" victory over corrosion in all forms—and at big savings too. In addition to being highly resistant to moisture and soil stress, Barrett Coal-Tar Primers and Enamels have built-in electrical insulation . . . to help cut your cathodic protection costs way down. And Barrett Pipeline Felt gives the surest, longest-lasting protection to the enamel coating. Let the Barrett Technical Assistance Group help you get the best coating combination on your next job. Write for information.
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A-5203

ALLIS-CHALMERS

PIPE LINE DEVELOPMENTS ★ ★ ★

Roundup of Planned and Proposed Construction

The following tables list the company, mileage, pipe size, and location of proposed pipe line projects — crude, products, and natural gas — reported to *The Pipeline Engineer*. Company addresses are given when known.

CRUDE LINES

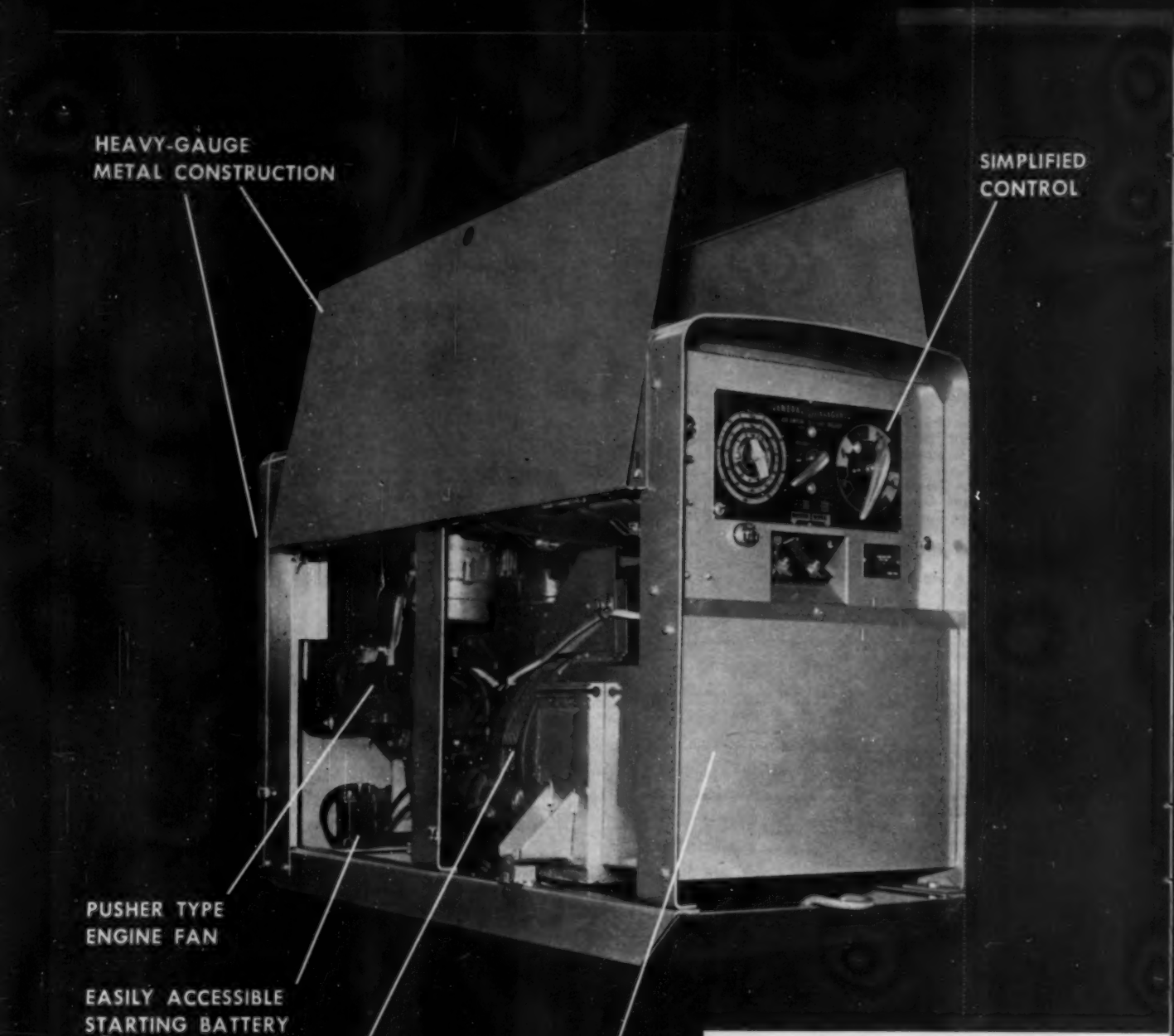
Name of Company	Miles	Size	Location
Canadian Gulf Pipe Line Company Tulsa, Oklahoma	35	—	Drumheller field to Big Valley
Humble Pipe Line Company Houston, Texas	100	18	Ector to Kemper, Texas
Interprovincial Pipe Line Company Toronto 1, Ontario, Canada	151 32.6	20 24	Sarnia to Port Credit, Ontario Regina, Saskatchewan, to Cromer, Manitoba
Kaybee Pipe Line Company Muskegon, Michigan	46	10	Griffith, Indiana, to New Buffalo, Michigan
Lakehead Pipe Line Company, Inc. Toronto 1, Ontario, Canada	80	26	Loop from Clearbrook, Minnesota, to Superior, Wisconsin
Northwest Pipe Line Corporation Houston, Texas	350	8	Four Corners area to Salt Lake City, Utah
Offshore Gathering Company Houston, Texas	364	20	Gulf of Mexico from Sabine Pass to Mississippi River
Pecotex Pipe Line Company El Paso, Texas	127.5	20	New loop on system from Wink to El Paso, Texas
Rangeland Pipe Line Company	44	6–12	Central Alberta to Rimbey
Royal Dutch Shell Group and Others The Hague, Netherlands	870 150 12	30 20 6	Marseille, France, to Rotterdam, Holland, and Antwerp, Belgium Mexia to Houston, Texas. Replacement of existing line North Madill field to Cumberland field terminal, Oklahoma
Royal Pipe Lines, Ltd. Regina, Saskatchewan, Canada	288	Var.	Cantuar area fields to Glenavon
Sinclair Pipe Line Company Independence, Kansas	150	20	Teague to Houston, Texas
Socony Mobil Oil Company de Venezuela and Sinclair Oil & Refining Company	211	20	Silvester field near Barines to Puerto Cabello, Venezuela
Stanmount Pipe Line Company	140	10	Beaver Lake field, North Dakota, to Cromer, Manitoba
Tecumseh Pipe Line Company Independence, Kansas	190	20	East Chicago, Indiana, to Cygnet, Ohio
Trans-Border Pipe Line Company	110	—	Skagway, Alaska, to Whitehorse, Yukon Territory
Union Oil Company Los Angeles, California	815 225	— 12–16	Shale oil plant at Rifle, Colorado, to Los Angeles area (being considered) Junction station to San Francisco, California

PRODUCTS LINES

Name of Company	Miles	Size	Location
Crescent Corporation Tulsa, Oklahoma	120	6	Tioga, North Dakota, to U. S.-Canadian border
El Paso Natural Gas Company El Paso, Texas	96.0	8	Gallup to Blanco Plant, New Mexico
Equitable Gas Company and Subsidiaries Pittsburgh, Pennsylvania	100	4–5	Maytown, Kentucky, to Institute, West Virginia
Hydrocarbons Pipelines, Ltd. Winnipeg, Manitoba, Canada	800	6–8	Alberta to Lakehead
Northwest Pipeline Corporation Houston, Texas	350	8	Four Corners area to Salt Lake City, Utah
Phillips Petroleum Company Bartlesville, Oklahoma	66 26	12 12	Loop line from Borger, Texas, to Cassoday, Kansas Loop line from Jefferson City, Missouri, to Eureka, Missouri
Shell Oil Company Los Angeles, California	16.5	4	Convert 13 miles of existing line and construct 3.5 miles new line from Wilmington Refinery to Los Angeles Marketing Depot
Southern Pacific Pipe Lines, Inc. Los Angeles, California	315	6–10	Richmond, California, to Fallon, Nevada
Texas Eastern Transmission Corporation Shreveport, Louisiana	1168	16–20	Conversion of "Little Inch" between Beaumont, Texas, and Moundsville, West Virginia
Winnipeg & Central Gas Company Winnipeg, Manitoba, Canada	210	6	U. S.-Canadian border to Winnipeg

GAS LINES

Name of Company	Miles	Size	Location
Alberta Gas Trunk Line Company, Ltd. Calgary, Alberta, Canada	34	18–34	Bindloss, Alberta, to Saskatchewan border
Andes Pipeline Corporation	500	12	Villamontes, Bolivia, to Antofagasta, Chile
Carolina Natural Gas Corporation Hickory, North Carolina	185	2–12	Additions in North and South Carolina
Cities Service Oil Company Bartlesville, Oklahoma	70	—	Gas gathering system on the Roberts Ranch, Midland, Texas



NOW—AVAILABLE IN 200-, 300-, 400-AMP MODELS

Prove it to yourself— Make this actual feature-by-feature comparison of General Electric engine-driven welders with two other lines of engine-driven welders. You will see that only the new G-E welders have so many advanced design features for better welding at lower cost.

EASILY PRESET Electrode Selector, Current Dial—Dual controls make current setting easier and more accurate.

GENERAL ELECTRIC	✓	
MANUFACTURER A		
MANUFACTURER B		

How General Electric's NEW Line of Engine-driven Welders Can Help You Meet Contract Deadlines

Advanced design assures less "downtime," minimum maintenance—for faster, lower-cost welding

Nothing stretches out construction time more than unreliable or obsolete equipment. Such equipment increases your maintenance costs and results in non-productive "downtime." It may even lead to contract fines and loss of repeat business.

To reduce construction delays, General Electric's new line of engine-driven welders has been designed and field-tested for maximum durability and minimum maintenance—without sacrifice in performance. These new 200-, 300-, and 400-amp welders save for you with the following advantages:

SAVE YOU TIME—Sturdy construction, the dependable Hercules engine, new-design generator, and simplified control all combine to give you steady output, longer operating time between overhauls, and reduced maintenance. This means more production per machine . . . per man-hour.

SAVE YOU MONEY—General Electric engine-driven welders begin saving you money the first day on the job. For example, the deep-sump crankcase provides complete lubrication to all moving engine parts—up to a 15-degree tilt in any direction. This helps to reduce costly breakdowns. And the over-all advanced design assures you of more and better welds at less cost, with a reduction in costly downtime for maintenance and repair. Additional General Electric advantages are described below.

For more information about how General Electric engine-driven welders can help you, contact your nearby General Electric Welding Distributor. He is listed in the yellow pages of your telephone book. Write for descriptive bulletin to Section 714-5, General Electric Company, Schenectady 5, New York.

Progress Is Our Most Important Product

GENERAL ELECTRIC

CONSTANT-PRESSURE Brush Springs—Right pressure maintained for life of generator brushes without adjustment.

PRELUBRICATED Generator Bearings—Ball bearings prelubricated with sufficient grease for years of service.

DEPENDABLE Geared Governor—Gear-driven governor maintains close speed regulation for best welding.

PUSHER-TYPE Engine Fan—Large diameter pusher-type fan circulates ample cooling air for engine and generator.

CONTROLLED CURRENT Peaks—Current peaks are controlled. Arc can be crowded with no "stumbling" or "freezing."

	✓	✓	✓	✓	✓
		✓	✓	✓	
				✓	

Name of Company	Miles	Size	Location
Coastal Transmission Corporation	562	22–26	McAllen, Texas, to Baton Rouge, Louisiana
Dallas, Texas	272	Var.	Gathering lines in Rio Grande Valley, Texas
Colorado Interstate Gas Company	345	30	Kit Carson, Colorado, to Beatrice, Nebraska
Colorado Springs, Colorado	100	24	Springfield to Pueblo, Colorado
	50	22	Hooker to Mocane and Laverne fields, Oklahoma
	24	24	Greenwood to Panhandle-Kit Carson loop
	109	20	Loop from Fourway, Texas, to Springfield, Colorado
	106	24	Loop from Springfield to Kit Carson, Colorado
	10	16	Keyes field, Oklahoma, to mainline
	6	10	Tablerock field, Wyoming, to mainline
	48.0	4–16	Additions in Mocane field, Oklahoma
	12.0	12–22	Additions in Texas Panhandle fields
El Paso Natural Gas Company	83.8	34	Loops to San Juan mainline extending from San Juan County, New Mexico, to Topock, Arizona
El Paso, Texas	20.5	30	Loops to existing Permian-San Juan mainline from Bluewater station to San Juan mainline in McKinley County, New Mexico
	8.3	26	Loops to California mainline in Yuma County, Arizona
	28.5	30	Field transmission line in San Juan Basin, New Mexico
	78.8	18	Field line from Carson County, Texas, to Moore County, Texas
	16.0	20	Line from South Andrews field, Andrews County, Texas, to existing Goldsmith Plant
Houston Texas Gas & Oil Company	28.1	10¾	From Nolan County, Texas, to Jameson field, Coke County, Texas
Houston, Texas	961	12–20	Baton Rouge, Louisiana, to Miami, Florida, laterals
Kansas-Nebraska Natural Gas Company, Inc.			
Hastings, Nebraska	10	10	Grand Island to Fullerton, Nebraska
	10	8	Loop from Grand Island to Fullerton, Nebraska
	11.5	12	Replacement from Scott City to Oakley, Kansas
	1.2	6	Additions to system in Nebraska
	9	8	Lexington to Central Nebraska Public Power Electric Plant
	14	16	Replacement from North Platte to Maxwell, Nebraska
Michigan Wisconsin Pipe Line Company	13.6	24	Looping in Wisconsin
Detroit, Michigan	10.4	24	Looping in Illinois
	471	4–24	Loops and extensions in Wisconsin and Illinois
Midwestern Gas Transmission Company	1112	12–24	Mainline from U. S.-Canadian border near Emerson, Manitoba — Noyes, Minnesota, to Portland, Tennessee
Houston, Texas	648	3–18	Laterals of mainline to serve communities in Minnesota, North Dakota and Wisconsin
Natural Gas Pipeline Company of America	349	20–26	Jack and Wise counties to Fritch, Texas
Chicago, Illinois	38	36	Joliet to Elgin, Illinois
	405	36	Beaver County, Oklahoma, to Joliet, Illinois (loops)
	25	—	Gathering line from Quinduno field, Roberts County, Texas, to point on existing line
	91	30	Loops in Nebraska, Kansas, Oklahoma
Northern Natural Gas Company	15	24	Loops on system in Nebraska
Omaha, Nebraska	28	24	Ogden to Redfield storage area, Iowa
	168	20	St. Paul-Minneapolis to Duluth, Minnesota, and Superior, Wisconsin
	163	10–12	Mainlines in South Dakota
	307	Var.	Branch lines in South Dakota, Minnesota, Iowa and Wisconsin
	100	20–24	Savannah Creek field, Alberta, to Alberta-Montana border near Cardston, Alberta
Northern Plains Natural Gas Company (subsidiary of Northern Natural Gas Company)	1100	26	Alberta-Montana border to Minneapolis, Minnesota
Omaha, Nebraska			
Offshore Gathering Company	364	30	Offshore gas line in Gulf of Mexico from Sabine Pass to Mississippi River
Houston, Texas			
Pacific Gas & Electric Company	83	12–20	Glenn County to Sacramento, California
San Francisco, California	150	34	Loops on Topock, Arizona, to Milpitas, California, system
Pacific Lighting Gas Supply Company	80	30	Coles Levee to Newhall
Los Angeles, California	2.1	16–20	Potrero to Newhall
	2.8	16	Lines in East Whittier
Southern Counties Gas Company Southern California Gas Company	241	30	Newhall to Topock, Arizona
Los Angeles, California			
Tennessee Gas Transmission Co.	100	—	New gathering lines in Texas and Louisiana
Houston, Texas	557	30	Mississippi River Delta south of New Orleans to Portland, Tennessee
	120	12,20,26	Kinder, Louisiana, south 68 miles into Gulf of Mexico
	332	26	Loops in Kentucky, West Virginia, Pennsylvania
	76	24	Coudersport, Pennsylvania, to Buffalo, New York
Texas Eastern Transmission Corporation	530	30	Loops from Kosciusko, Mississippi, to Uniontown, Pennsylvania
Shreveport, Louisiana	45	24	Provident City, Texas, to McAllen-Vidor line near Blessing
	422	30	McAllen to Vidor, Texas
	141	Var.	Supply laterals from South Texas area to McAllen-Vidor line
	10	12	Loop from Broadaxe Junction to Levick Street, Philadelphia, Pennsylvania
	6	12	Loop from Broadaxe Junction to Conshohocken, Pennsylvania
	5	10	South Plainfield to Highland Park, New Jersey
Texas-Illinois Natural Gas Pipeline Company	59	20	Joliet to Volo, Illinois
Chicago, Illinois			
Trans-Canada Pipe Lines, Ltd.	1675	30–34	Winnipeg to Montreal and laterals
Calgary, Alberta, Canada			
Trans-Carolina Pipe Line Corporation	840	2–18	New line between Moore, South Carolina, and Morse, North Carolina with laterals
Raleigh, North Caroline			
Transcontinental Gas Pipe Line Corporation	181	36	Loops on system
Houston, Texas	51	30	Loops on system

Clevelands dig through swamps and hills for 327-mile 18" products line in working space only 35' wide

Oklahoma Pipe Line Constructors are cashing in on the compact design, reversible discharge conveyors and rugged digging ability of their Cleveland trenchers in the construction of this 18" products line for the Plantation Pipe Line Company. Construction operations are restricted to a working space only 35 feet wide because pipe is being laid alongside existing 12 and 18" lines under load in the original right-of-way. Two Clevelands are being used to cut trench 42 to 54 inches deep for the 327-mile line extending through swamps and rolling hills from Baton Rouge, La. to Helena, Ala., near Birmingham.

• The Cleveland 240, shown above, is only 8-feet wide over its non-packing, bearing-sealed crawlers—a perfectly balanced, powerful trencher that easily negotiates the wettest rights-of-way and overcomes the toughest hills—digs up to 3 feet in width and down to 6 feet, 3 inches in depth.

Good Everywhere

THE CLEVELAND TRENCHER COMPANY

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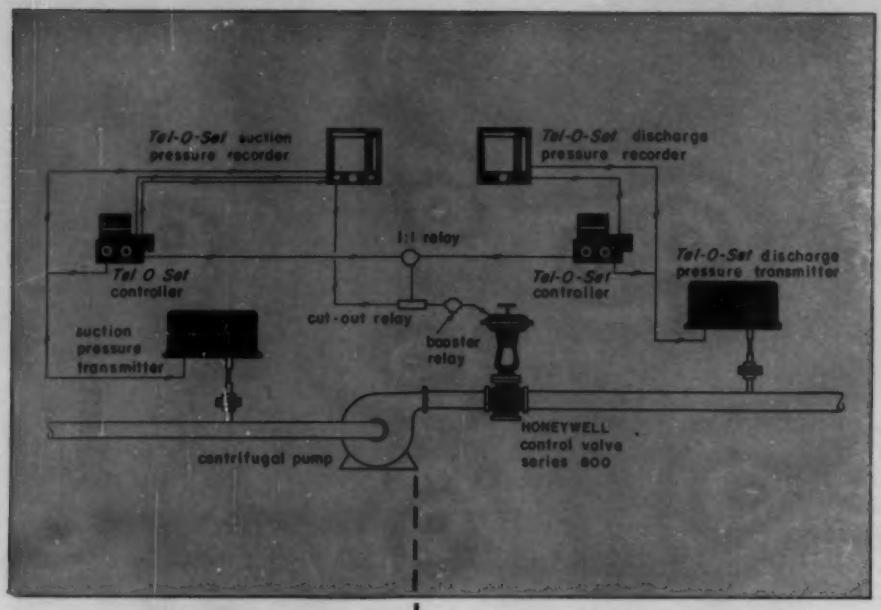
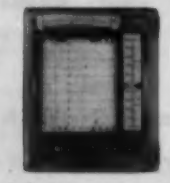


Typical *Tel-O-Set* instrumentation for a centrifugal pump uses a combination of transmitter, recorder and controller for both suction and discharge pressure. Systems are interlocked through a relay to operate a Honeywell Series 800 control valve.

***Tel-O-Set* transmitter**

sends air signal to recorder. It's fast, accurate, compensated for changes in ambient temperature and pressure. Zero and span readily adjustable.



***Tel-O-Set* recorder**

is accurate, sensitive, compact. All adjustments made from front of panel. Complete chassis is replaceable . . . no loss of control. 30-day chart record.

***Tel-O-Set* controller**

has fast response, is unaffected by vibration. Disconnects at turn of a single switch. Each sub-assembly is a precalibrated unit, interchangeable in seconds.

FULL-TIME CONTROL

...For Pipeline Pumping Stations

Put a *Tel-O-Set* control system to work on your pumps—and you're sure of uninterrupted service. When instrument maintenance is needed, the job gets done in seconds.

The reason: transmitter, recorder and controller are designed with quickly interchangeable unit sections. You just put in a new, precalibrated unit when needed.

In performance, too, *Tel-O-Set* miniature instrumentation leads in every respect. It's accurate, sensitive, rugged. It's exceptionally easy to tune for peak operation.

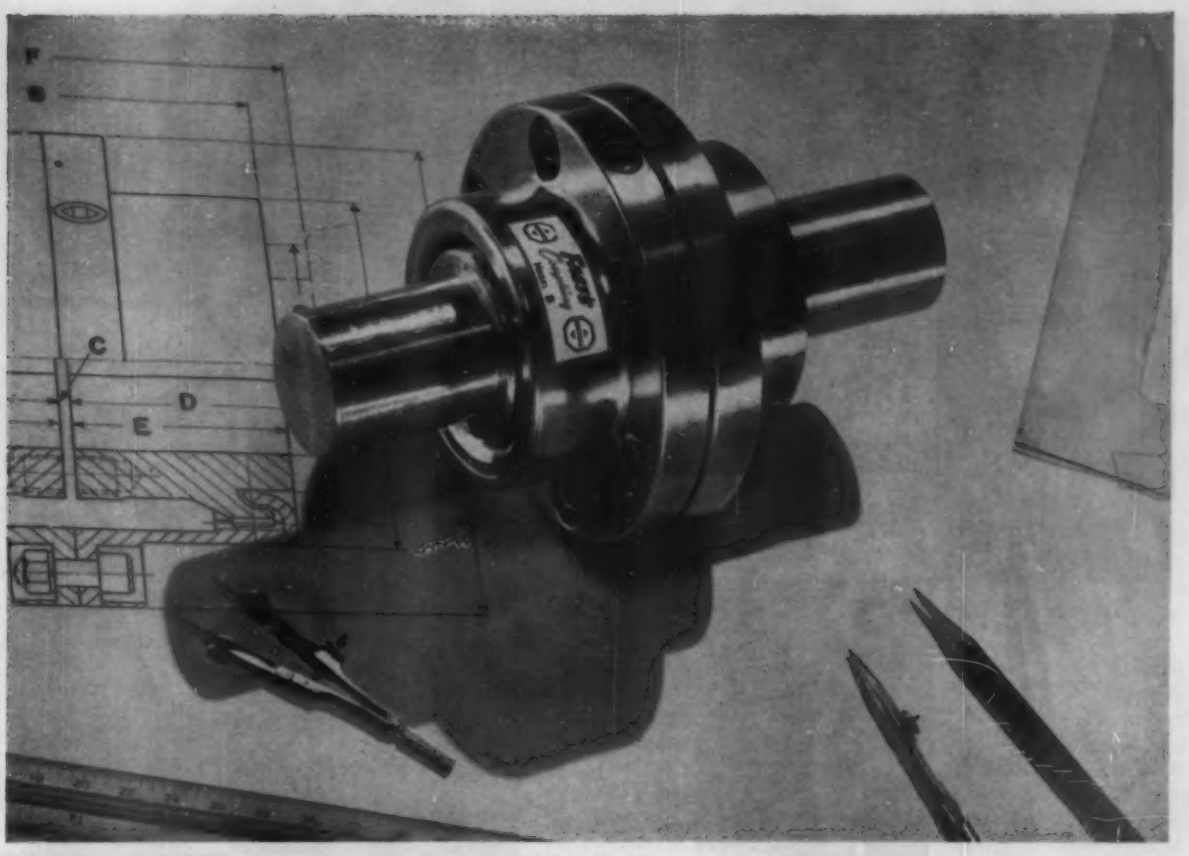
Find out from your local Honeywell sales engineer how *Tel-O-Set* instruments can be applied to your station. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa. —in Canada, Toronto 17, Ontario.

MINNEAPOLIS **Honeywell**

BROWN INSTRUMENTS

First in Controls



Now for the first time, a Fast's Coupling for light and medium drives—at a new low cost!

It's the new Fast's Coupling MODEL B—a lighter, smaller coupling with all the famous Fast's features never before available at such a low cost!

The new MODEL B fills the needs of manufacturers of fans, blowers, pumps and other light-to-medium drive units where coupling *cost* is as important as performance. Koppers engineers designed it to eliminate the cost barrier and offer Fast's rugged design and trouble-free performance for hundreds of new applications.

All steel, dust and moisture proof with metal-to-metal seal, Fast's MODEL B is available for shaft sizes up to 2⅝". Like all Fast's Couplings, it's *sold with service* . . . Koppers *free* engineering service that guarantees the right coupling for the job.

The new Fast's MODEL B Coupling may offer a profitable solution to your light or medium drive coupling problems. Find out how by writing for full details to: KOPPERS COMPANY, INC., Fast's Coupling Dept., 3211 Scott St., Baltimore 3, Md.

THE ORIGINAL **FAST'S Couplings**

KOPPERS

METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC. • BALTIMORE, MD. This Koppers Division also supplies industry with American Hammered Industrial Piston and Sealing Rings, Koppers Electrostatic Precipitators, Aeromaster Fans and Gas Apparatus. Engineered Products Sold with Service

KOPPERS COMPANY, INC., *Fast's Coupling Dept.*, 3211 Scott St., Baltimore 3, Md.
Gentlemen: Please send me more detailed information on the new Fast's Coupling MODEL B.

Name.....

Company.....

Address.....

City.....Zone.....State.....

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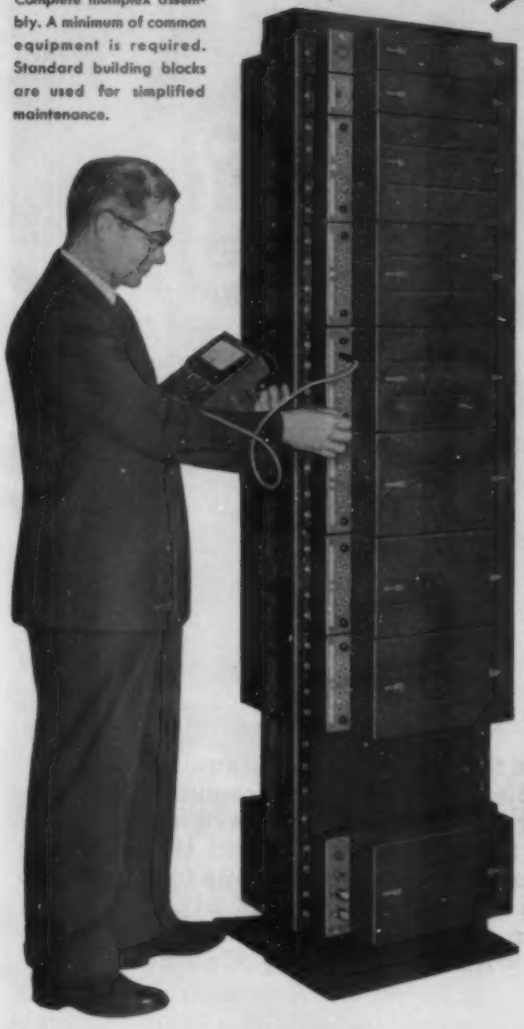
NOW... Big News in Microwave Multiplex Channeling Equipment!

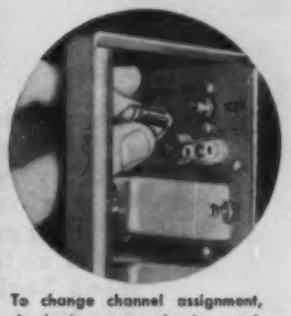


Complete multiplex assembly. A minimum of common equipment is required. Standard building blocks are used for simplified maintenance.

New RCA Type MV-124 with All Channel Units Identical and Interchangeable

Specifically designed for microwave use and thoroughly field tested, this new RCA Channeling Equipment provides complete flexibility. Frequency selection is by means of a plug-in crystal. Except for this crystal, *all Channel Units are identical and interchangeable*, thus simplifying planning, installation and maintenance.

Whatever your channeling requirements, these famous quality Channel Units can be easily stacked to provide two channels, three channels, or up to 24 voice channels without group modulating. High capacity systems can be obtained by stacking 24 channel groups. One unit is required for each voice channel desired. Single sideband suppressed carrier techniques are used to supply 24 channels in the band between 10 kc and 130 kc frequency, leaving frequency space for 18 tone channels below 10 kc. Simultaneous transmission of many channels of intelligence is accomplished by modulating separate sub-carriers spaced uniformly throughout the base-band modulating system. Channels are spaced one above the other in the available modulating band width.



To change channel assignment, simply change one plug-in crystal.

CRYSTAL CONTROL assures high stability and greater accuracy. For operations such as frequency shift telegraph and facsimile transmissions, an unusually high degree of clarity is attained.

DOUBLE HETERODYNING enables all circuits in all units to be identical except for the plug-in crystal element.

SINGLE SIDEBAND OPERATION enables each channel to use a minimum of spectrum space. This means less obsolescence due to possible congestion of the available microwave spectrum.

RCA Microwave . . . performance-proved in more than a million channel miles of operating systems throughout the world.

RCA Microwave Specialists will be glad to answer any questions and help plan your installation. Nation-wide services of the RCA Service Company are provided to keep entire system operating at its peak. Mail coupon for further particulars.

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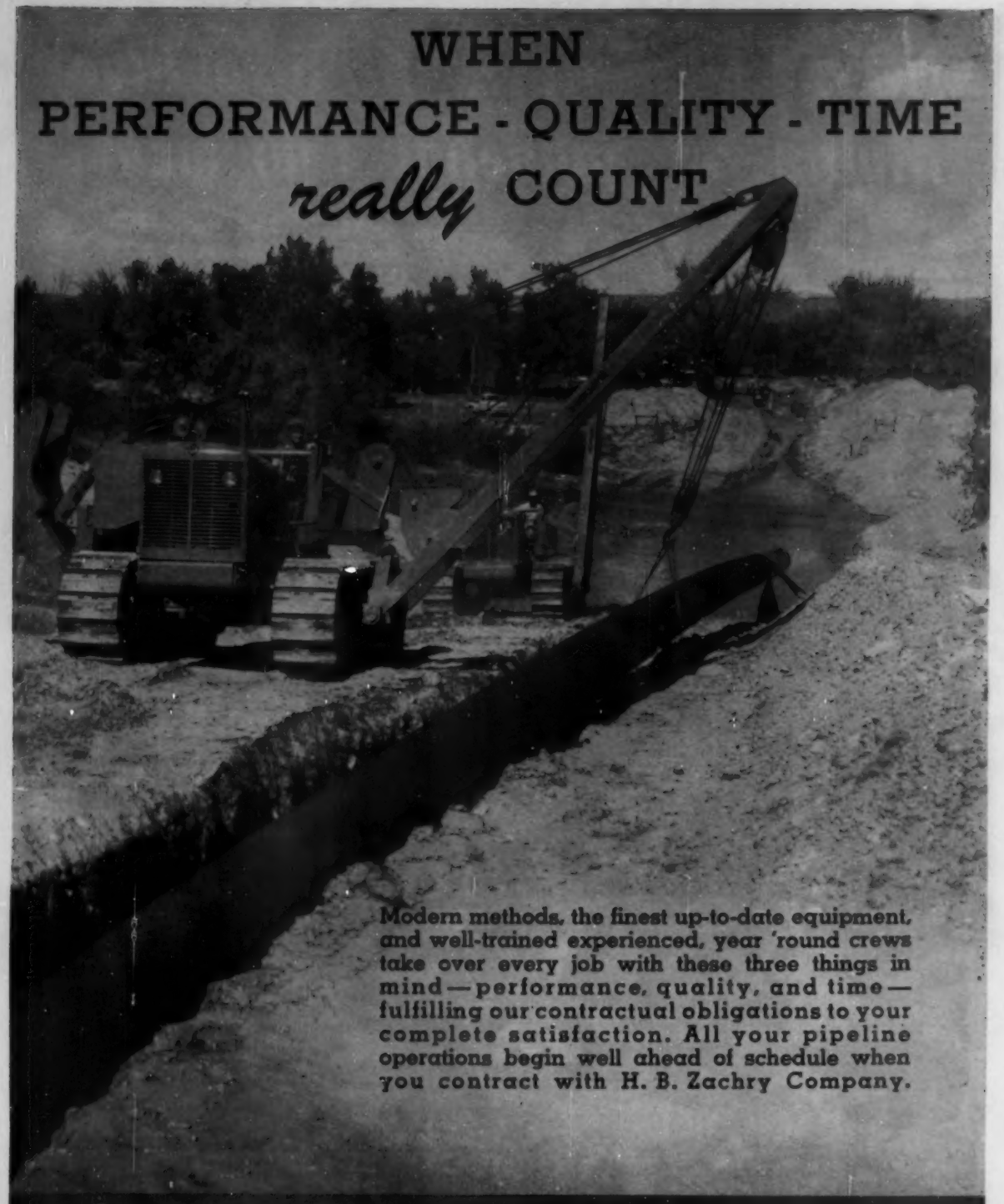

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With Armco Steel Pipe you get all the pipeline mileage you pay for. There are 132 different combinations of diameter and wall thickness to help meet your requirements exactly. You never need to compromise with the "next larger size."

You save, too, by ordering Armco Pipe in standard 50-foot lengths instead of the usual 40-foot or double random lengths. This means at least 20 per cent fewer field joints and you have fewer sections to handle.

Use Armco Welded Steel Pipe for requirements in the Natural Gasoline and Natural Gas Divisions and wherever else you need dependable line pipe.

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"Something from the Irishman"

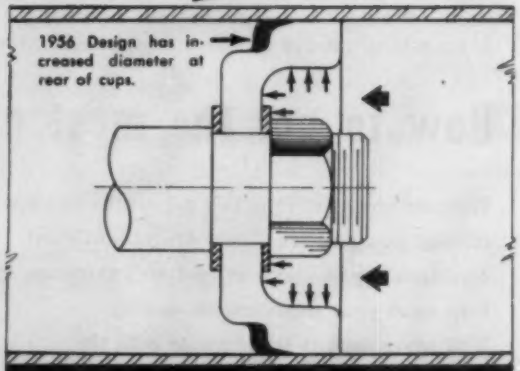
The NEW, IMPROVED DESIGN

of Maloney scraper cups assures long life and even wear

Service has proved the cup ideal for "out of round" and varying weight pipe due to the flexibility and parallel faces of the cup lip. Flexibility is accomplished by the design at the back of the cup, which permits the wiping surface to expand or contract and follow the pipe contour.

The parallel faces of the lip give longer life to the cup and maintain the effective length of the wiping surface, regardless of wear. The parallel faces also give uniform pressure. Competitive cups having a sharp edge do not wear evenly and as wear takes place, the length of the wiping surface decreases.

Maloney scraper cups are manufactured from a selected Neoprene compound, have excellent abrasive qualities, proper flexibility and retain dimensional stability under all service conditions. The Maloney 1956 design has increased the diameter at rear of cups.



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UNDERCOVER AGENTS AT WORK

Dependable protection against underground corrosion is one of the most essential considerations in the installation of any pipeline. This protection usually consists of an insulating, corrosion-inhibiting coating applied to the pipe surface, with further shielding provided by a wrapper to resist abrasion and soil stress. These are the "undercover agents" that safeguard pipeline installations against corrosion leaks and deterioration.

Throughout the nation today, leading utilities and pipeline companies look to Dearborn for long-term protection of one of their most important investments—the carrier pipe that must transmit material thousands of miles to its consumer. Dearborn's NO-OX-ID Coatings and NO-OX-IDized Wrappers provide chemical and mechanical protection against moisture penetration and soil action—protection that lasts for decades—on installations under ground or under water.

Whether applied by hand . . . by Traveliner . . . or at the mill, Dearborn Coating Combinations are your best assurance of dependable, long-life protection. On your next pipe-coating job, you'll find it pays to specify Dearborn NO-OX-ID.

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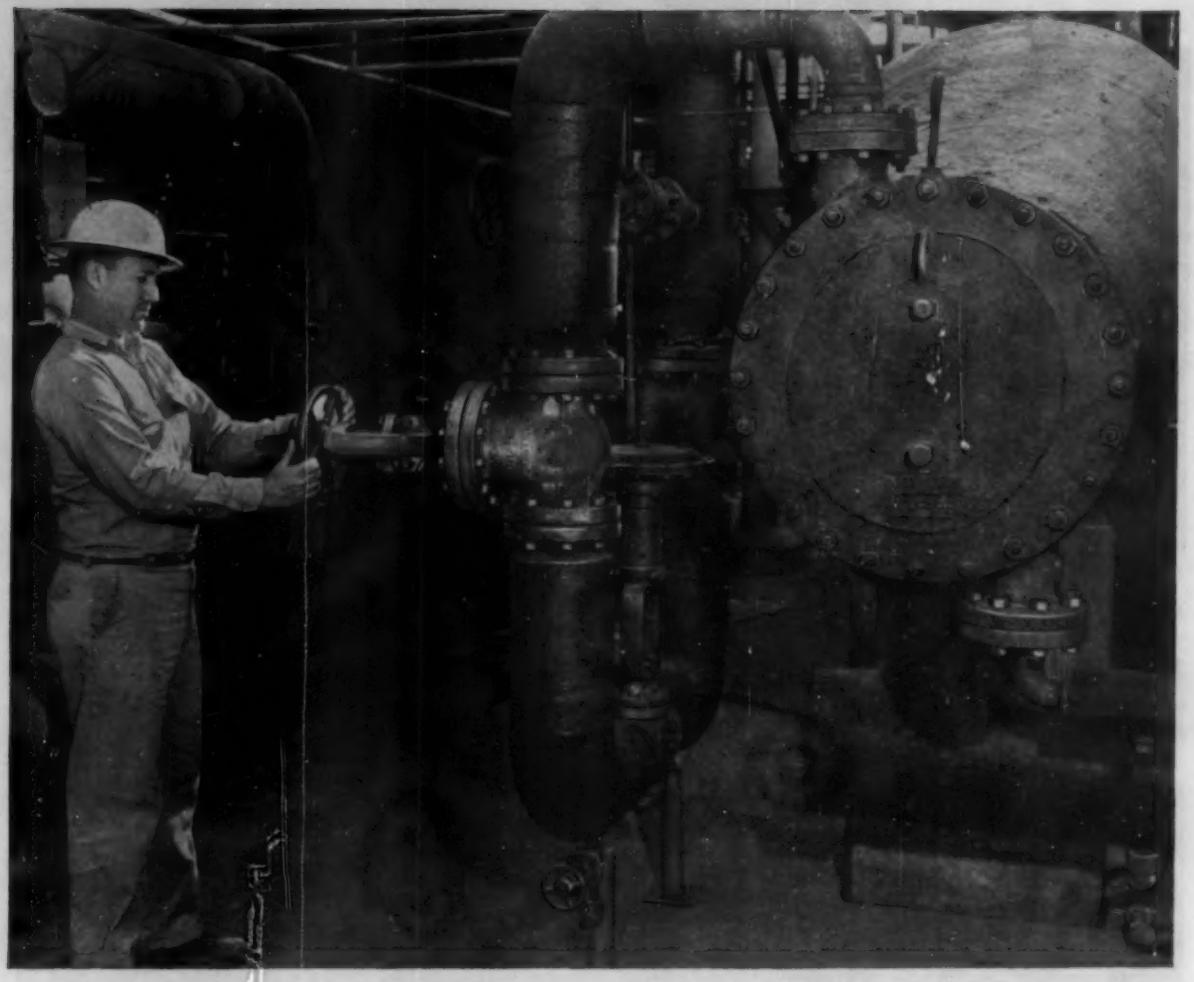

This Crane valve joins the "12-year service club" on steam

Valve performance like this looks good on any plant's cost sheets.

In 1944, Eastern States Petroleum Company installed this Crane 4-inch 33XR steel gate valve in its Houston refinery, handling 150 pounds of steam at 375° F. It's a busy valve—operation is frequent.

Despite the fact that this Crane valve has an even dozen years of severe service—with opening and closure at close intervals—*no* maintenance or service has been required except repacking.

Before you lift an eyebrow in surprise, consider the fact that Crane valves have performance records like this throughout industry, on all types of flow control. There's a logical reason, of course: Crane valves are strictly quality *all* the way—from research and engineering through precision manufacturing, assembly and testing methods.

Any wonder why men who know valves say *Crane is the name to depend on?* Don't gamble with your all-important flow control—specify Crane valves and fittings from the world's largest line, built with a century of matchless experience. Get the facts from your local Crane Representative, or write to the address below.

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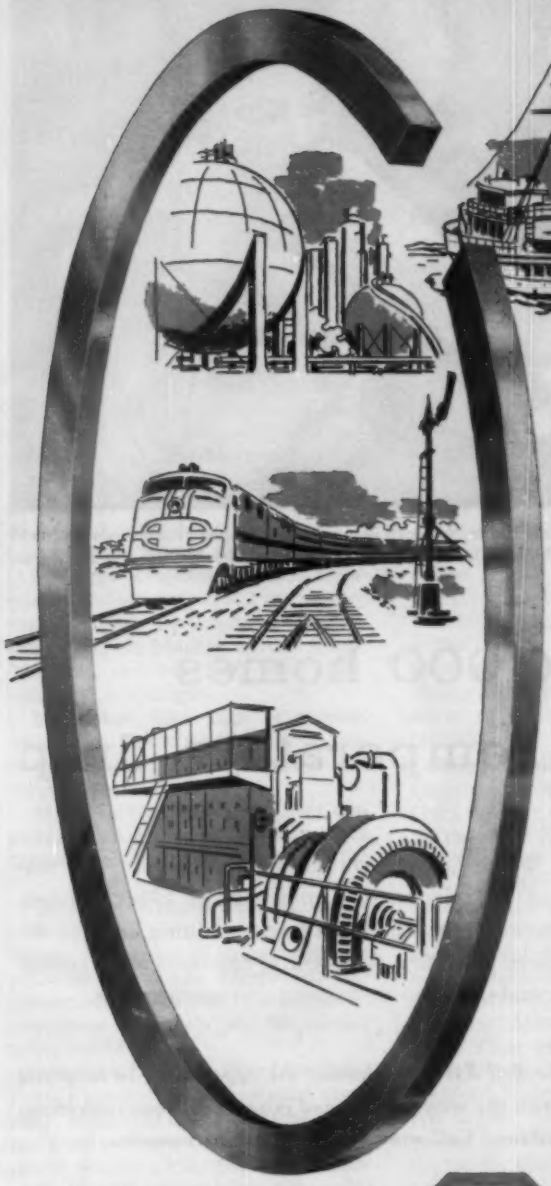
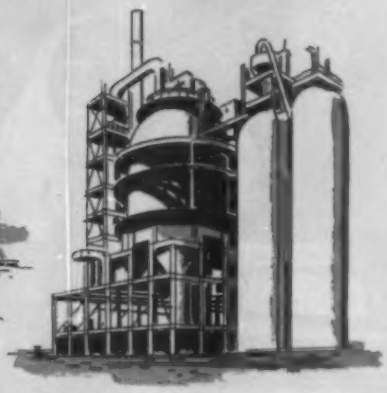
field-tested money savers!





Why not specify piston rings that have *proved* themselves? Koppers rings have been saving money and cutting costs for years—throughout the oil and gas industry, the marine industry, on major railroads, all over the chemical field, throughout the aircraft business, in municipal and industrial power plants everywhere—wherever you find gas, Diesel or steam engines, pumps, compressors, forging hammers—*wherever piston rings are needed!*

They're built to take it . . . designed to cut downtime and maintain high compression . . . give longer, more satisfactory service . . . save you money on fuel and lubricating oil . . . *and that's exactly what they do.* And Koppers rings are available in all types, all sizes—from ½" to 10' diameter—specifically designed for the job they will do in the field where they will be used.

Always specify American Hammered Piston Rings. Benefit from over 100 years of experience in metal products. Use Koppers' complete engineering and metallurgical staff. Get skilled analysis of your specific problem, and prompt assistance. For 16 page Piston Ring booklet write to: KOPPERS COMPANY, INC., *Piston Ring & Seal Dept.*, 1711 Hamburg Street, Baltimore 3, Maryland.

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Industrial Piston Rings

Hourly pressure information is transmitted from Northern Natural Gas Company compressor and field dispatch station to chief dispatcher's office in Omaha, Nebraska, by Bell System private line telephone.

How they protect 800,000 homes from a sudden temperature drop

There's a sudden drop of temperature in the Dakotas—and dispatchers of the Northern Natural Gas Company swing into action—to assure normal gas pressures for local distributing companies serving 800,000 domestic users through 10,000 miles of pipeline all the way from New Mexico to Minnesota!

Dispatchers, using Bell System private line telephone facilities, ask certain large industrial users to switch temporarily to other fuels.

Then, through contact with 35 compressor stations by telephone, dispatchers at Omaha headquarters direct the additional gas thus gained to the desired localities. A potential emergency is handled in stride, thanks to modern communications.

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The Bell System welcomes the opportunity to help you obtain the most reliable and economical communications facilities. Call your Bell System representative.

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American Louisiana—

Newest Member of American Natural Gas Family

ANGC

Serving 500,000 Customers Requires Tremendous Pipe Line Capacity

Dean Hale, *Technical Editor*

AMERICAN Natural Gas Company is an integrated natural gas system consisting of two large natural gas distributing companies and two interstate gas transmission companies. Together, these companies provide natural gas for a population of more than 4,800,000 persons, and the system is now able to deliver approximately 1.75 billion cu ft of gas on a single day.

McElvenny

American Natural subsidiaries are:

Michigan Consolidated Gas Company, distributor of natural gas to more than 815,000 customers in Detroit, Grand Rapids, Muskegon, Ann Arbor, Ysilanti, and over 100 other communities in Michigan.

Milwaukee Gas Light Company, which distributes natural gas to approximately 245,000 customers in Milwaukee and its environs.

Michigan Wisconsin Pipe Line Company, which owns and operates a gas transmission line extending from the Panhandle-Hugoton field in Texas and Oklahoma to Wisconsin and Michigan. The pipe line company sells approximately 80 per cent of its gas to its two affiliated distributing companies, and the remainder is sold to 14 other utility companies in Michigan, Wisconsin, Iowa, and Missouri.

American Louisiana Pipe Line Company, a natural gas transmission company, completed a new 1200-mile pipe line from southern Louisiana to Michigan in August, 1956. About two-thirds of its 300,000,000 cu ft per day capacity is sold to Michigan Consolidated at Detroit and the remainder is sold to Michigan Wisconsin Pipe Line Company.

American Natural was formed in 1901 as the American Light and Traction Company and changed its name to American Natural Gas Company in 1949.

Officers of American Natural are: President, Ralph T. McElvenny; vice president and treasurer, F. W. Sharp; vice president and secretary, Dudley B. W. Brown; assistant secretary and assistant treasurer, Parker M. West; general counsel, John Dern.

Directors include McElvenny, Sharp, Brown, Dern, William Chamberlain, Clifton G. Dyer, Henry Fink, Stanhope Foster, C. A. Johnson, Donald R. Richberg, Hubert R. Schaddelee, Richard Schaddelee, Henry Tuttle, and Ben E. Young.

The American Natural Gas Company is a New Jersey corporation with offices at 165 Broadway, New York. The company has paid dividends on its common stock each year for more than half a century. The common stock is listed on the New York Stock Exchange. Its utility property and other assets aggregate in excess of $600,000,000.

Ralph T. McElvenny became chief executive officer of American Natural Gas Company in April, 1954, succeeding the late William G. Woolfolk. He is also chairman of American Louisiana Pipe Line Company, Michigan Wisconsin Pipe Line Company, Michigan Consolidated Gas Company, American Natural Gas Service Company, and additionally is a member of the board of the American Natural Gas Company, Milwaukee Gas Light Company. These are affiliated companies.

McElvenny was graduated from Stanford University in 1928 with an AB degree, and from Stanford University Law School in 1930 with a JS degree. He started work that same year with Guaranty Trust Company of New York. In 1933 he went to Washington, D. C., as a conservator in the office of controller of currency. The following year he joined the staff of the Securities and Exchange Commission.

Returning to private business in 1945, he associated himself with the United Light and Power System, Chicago. In 1950 he was transferred to Detroit to work with the companies in the system of American Natural, which previously had been a subsidiary of United Light and Power.

McElvenny is featured in this issue as the "Petroleum Profile" of the month. His complete history will be found on Page A-8.

Henry Fink, president of Michigan Wisconsin Pipe Line Company and American Louisiana Pipe Line Company, is an engineer with more than 41 years' experience in all phases of the gas business.

During the past 21 years he has served the American National Gas system in many important management capacities. He was president of Michigan Consolidated Gas Company from 1946 to 1952. He served as president of American Natural Gas Company from 1948 until 1953 and has been president of Michigan Wisconsin Pipe Line Company since May, 1948. In 1953 he was elected president of American Louisiana Pipe Line Company.

Fink is also a director of the parent American Natural Gas Company and is a director of all American Natural system companies.

Wilber H. Mack is secretary, vice president, general attorney, and a director of Michigan Wisconsin Pipe Line Company and American Louisiana Pipe Line Company, and general attorney and a director of American Natural Gas Service Company. Prior to joining this group in 1952 he was assistant director of the Corporate Finance Division, Securities and Exchange Commission, Washington, D.C.

Educationwise he received an AB degree from Dartmouth College in 1932 and an LLB degree from George Washington University Law School in 1935. He was admitted to the District of Columbia Bar in 1935. From that date until 1942 he served in various legal capacities with the U.S. Securi-

ties and Exchange Commission. From 1942-48 he was a lieutenant commander in the U.S. Navy with the Office of Naval Intelligence.

Dudley B. W. Brown, vice president and secretary of American Natural Gas Company, began his career with the American Natural Gas system in Milwaukee in 1949.

He served there as vice president, executive vice president and president of Milwaukee Gas Light Company until 1955, when he was elected to his present post.

Brown is a graduate of Harvard College and Harvard Graduate School of Business Administration. He was with the U. S. Department of Agriculture until 1936, when he went into the sugar industry. He was first elected a director of American Natural in 1939.

Vice president and treasurer of American Natural Gas Company is **F. Wayne Sharp,** who joined the system in 1944 as first assistant treasurer. He is also a director of the company.

Sharp graduated from the University of Illinois in 1926, and is a certified public accountant. He served as a specialist on public utility matters with Arthur Anderson & Company from 1929 until 1944.

He was elected treasurer of American Natural in 1945 and was named a vice president in 1949. He is also vice president and treasurer, and a director of Michigan Wisconsin Pipe Line Company, and is a director of Milwaukee Gas Light Company.

Frank W. Thompson is vice president and director of American Louisiana Pipe Line Company. He also is vice president of Michigan Wisconsin Pipe Line Company and vice president and engineer of the American Natural Gas Service Company.

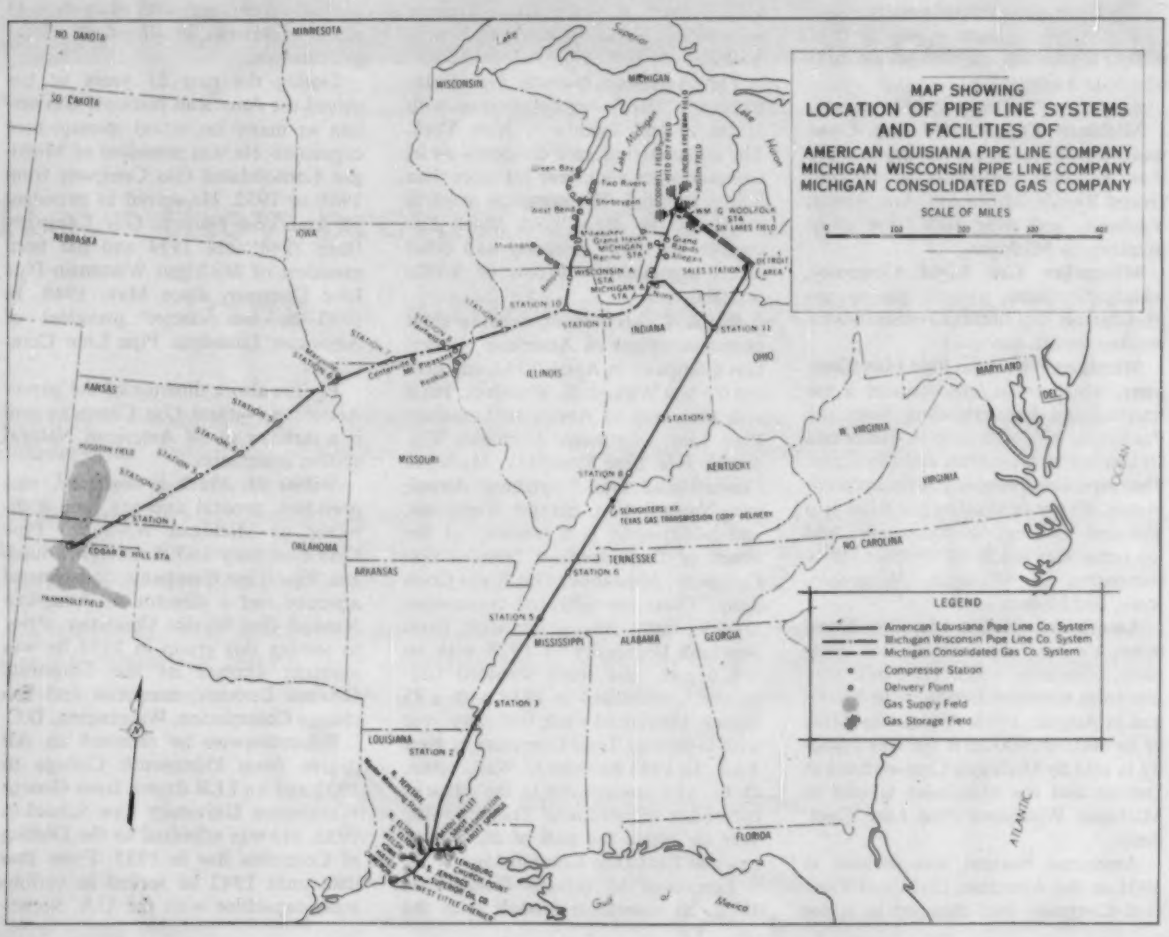
Thompson is a graduate of the California Institute of Technology with a BS degree in mechanical engineering.

His experience includes a number of years in the gas and oil fields of California. He was with the Los Angeles Gas and Electric Corporation, now the Southern California Gas Company, for six years. He also had regulatory experience with the California Public Utilities Commission and was a consulting engineer with the Federal Power Commission.

Thompson joined the American Natural Gas system in February, 1950. In the American Louisiana project, he participated in the negotiations of the gas purchase contracts and was responsible for the design and engineering.

Robert D. McClintock, vice president and manager of construction of American Louisiana Pipe Line Company, was graduated from Colorado College in 1936 with a degree in geology and a minor in civil engineering. He was employed in 1936 by Colorado Interstate Gas Company as field engineer. He was construction superintendent of this company at the time he left their employ in 1949. In February, 1949, he joined the engineering firm of Ford, Bacon & Davis, Inc., of New York and was division engineer for the construction work being performed by that firm for Michigan Wisconsin Pipe Line Company. From October, 1949, until April, 1951, McClintock was employed as pipe line superintendent for Michigan Wisconsin Pipe Line. In April, 1951, he was appointed manager of Wisconsin operations. In December, 1953, he was elected to his present position.

Herbert H. Ross, manager of operations, joined Michigan Wisconsin Pipe Line Company on April 1, 1956. He was previously associated with the Fish



Fink

Mack

Sharp

Brown

Frank Thompson

McClintock

Ross

Dern

Campbell

J. L. Thompson

Steinbaugh

McIntire

Service and Management Corporation.

Ross has rich experience in public utility operations. He is a mining engineer graduate of Ohio State University, and accepted his first job as field foreman and general superintendent for the National Gas & Electric Corporation. In 1931, the firm appointed him manager of their property in Ohio. Two years later he was elected vice president of the company, and served in this capacity until 1941, when he was elected vice president and general manager of the parent company.

In June, 1943, Ross accepted the appointment of manager of operations for the Oklahoma Natural Gas Company, Tulsa, Oklahoma. He was elected vice president and manager of operations in 1945. He retained this executive position until August, 1954, when he joined the Fish Service and Management Corporation as vice president.

John Dern, partner in the law firm of Sidley, Austin, Burgess & Smith, was born in Salt Lake City, Utah, July 26, 1903. He was graduated from the University of Pennsylvania (BS in economics, 1924; LLB 1927); admitted to New York bar in 1927, Illinois bar in 1930. In 1949 and 1950 he served as president of The United Light and Railways Company and Continental Gas & Electric Corporation, to expedite the liquidation of those companies.

Dern is general counsel and a director of American Natural Gas Company and American Natural Gas Service Company; director of American Louisiana Pipe Line Co., Michigan Consolidated Gas Co., Michigan Wisconsin Pipe Line Co., Milwaukee Gas Light Co.

Rex V. Campbell, general superintendent of American Louisiana Pipe Line Company, has had a long-time career in the gas industry dating back to 1935. In May of that year he began working for Cities Service Gas Company as a machinist. He advanced through various positions with the company and was construction superintendent of compressor stations and dehydration plants when, in 1943, he went with Panhandle Eastern Pipe Line Company as assistant superintendent of compressor stations. In July, 1949, he accepted a position with Ford, Bacon & Davis, Inc. as assistant superintendent of compressor stations in constructing Michigan Wisconsin Pipe Line. In November of that year he became superintendent of compressor stations for Michigan Wisconsin, which position he held until transferred to American Louisiana and his present job in September, 1955.

J. L. Thompson, general superintendent, Michigan Wisconsin Pipe Line Company, has been associated with the natural gas industry for 23 years.

He graduated from Rice Institute in 1933, and in later years has taken graduate work at Massachusetts Institute of Technology and University of Michigan. He is a registered professional engineer in the state of Texas.

Thompson began his career in the natural gas industry in 1933, when he joined the Lone Star Gas Company in Dallas, Texas. During the 18 years he was employed at Lone Star, he was engaged in all phases of natural gas operations.

For many years active in natural gas production, transmission, and storage research work, Thompson was elected 1955 Chairman of the AGA Pipeline Research Committee.

Varnum B. Steinbaugh is in charge of the acquisition of gas supplies for the American Gas Company system.

In March, 1952, Steinbaugh was authorized by the board of directors of the American Natural Gas Company to make a survey and recommendations for the location of a new natural gas pipe line to supply additional natural gas for the American Natural system. As a result of this survey the American Natural board in June, 1952, determined that the Louisiana Gulf Coast was the most feasible location for the line.

He participated in all gas supply purchases from American Louisiana and in the coordination of construction of this new line.

Steinbaugh has a BS degree in chemical engineering from the University of Michigan, 1921, and has been associated with American Natural affiliated companies since 1941.

Fred H. McIntire, assistant to the president, American Louisiana Pipe Line Company, was born in Wilson County, Texas, November 6, 1914. He is a graduate of Texas College of Arts and Industries; BS and MS in physics, 1938 and 1939 respectively. He was a member of the faculty of Texas A&I 1939 to March, 1941.

In March, 1941, he was appointed as special agent for the Federal Bureau of Investigation. While in the FBI, McIntire served as a special agent in Washington, D.C., and Oklahoma City, Oklahoma, and served as an assistant special agent in charge of the Oklahoma City, San Antonio, and Atlanta offices. He served as special agent in charge of the San Antonio, San Diego, and Detroit offices, and as inspector in charge of the Inspection and Planning Section of the FBI at Washington, D.C.

McIntire resigned from the FBI at Detroit, where he was serving as special agent in charge, in July, 1955. He was appointed to his present position August, 1955. ★ ★ ★

Greenville, Mississippi, compressor station, with vent bearing the American Louisiana name showing prominently in the foreground.

P 623

AMERICAN LOUISIANA

Surveys to Service In Rapid Time

1200 miles of line; 30,000 hp in three compressor stations; 300,000,000 cu ft capacity

OUT of the gas rich fields of the delta country and westward in South Louisiana, natural gas today is flowing through a thousand mile artery northward to one of the nation's great industrial areas. Through the combined efforts of many men from all walks of life, natural gas is being made available to thousands of new customers in the Michigan and Wisconsin area. A mere vision in 1953 is a reality in 1956.

That's the story of the American Louisiana Pipe Line Company.

As early as 1953 American Natural Gas Company saw that the demand for natural gas in its service area was growing at such a rate that a materially increased supply would be required for home and industry in the near future.

To insure facility of operation and an adequate supply for years to come, it was felt that the new supply should be in the prolific gas fields of southern Louisiana and the adjacent offshore area of the Gulf of Mexico. This would give the American Natural Gas system access to the two greatest known gas producing areas, as Michigan Wisconsin Pipe Line, a subsidiary, receives its supply from the Hugoton field.

To do the job of bringing this gas north, American Natural formed a new and separate subsidiary — American Louisiana Pipe Line Company.

Approximately 2.5 trillion cu ft of natural gas reserves were contracted in southwestern Louisiana and on November 10, 1953, American Louisiana filed an application before the Federal Power Commission for a certificate of public convenience and necessity.

After lengthy hearings, the FPC on October 1, 1954, issued its Opinion No. 276, which authorized American Louisiana to construct a new natural gas transmission system approximately 1200 miles in length to extend from Cameron, Louisiana, to Detroit. Several months of litigation followed and finally, in the summer of 1955, construction began on American Louisiana. This construction was completed August 15, 1956.

Expansion Planned

Since filing its initial application with the FPC, American Louisiana has increased its dedicated reserves to approximately 4 trillion cu ft. On May 12, 1956, during construction, American Louisiana filed an application with the FPC seeking authority to increase its capacity from 300,000,000 cu ft per day, its initial capacity, to 360,000,000 cu ft per day by November 1, 1956, and to 400,000,000 cu ft per day by July 1, 1957.

This orderly expansion calls for construction of 35.8 miles of 8-in. gathering lines, construction of two new compressor stations of 12,000-hp each, and the addition of 2000-hp to each of two presently existing stations. This construction covers the first increase.

Two additional compressor stations

of 10,000 and 8000-hp respectively will be constructed to complete the second phase. Cost of construction on both phases will be approximately $16,-078,000.

The initial 300,000,000 cu ft per day of American Louisiana gas is being delivered to Michigan Consolidated (200,000,000 cu ft per day) and Michigan Wisconsin (100,000,000 cu ft per day). By order dated August 8, 1956, the FPC approved the first phase of this expansion program and instructed that the 60,000,000 cu ft per day increase to be brought about by this expansion should be delivered 55 per cent to Michigan Wisconsin and 45 per cent to Michigan Consolidated.

The initial 300,000,000 cu ft per day of American Louisiana gas has increased Michigan Consolidated's supply by 70 per cent and has doubled the natural gas available to Michigan Wisconsin's 16 utility customers in Michigan, Wisconsin, Iowa, and Missouri.

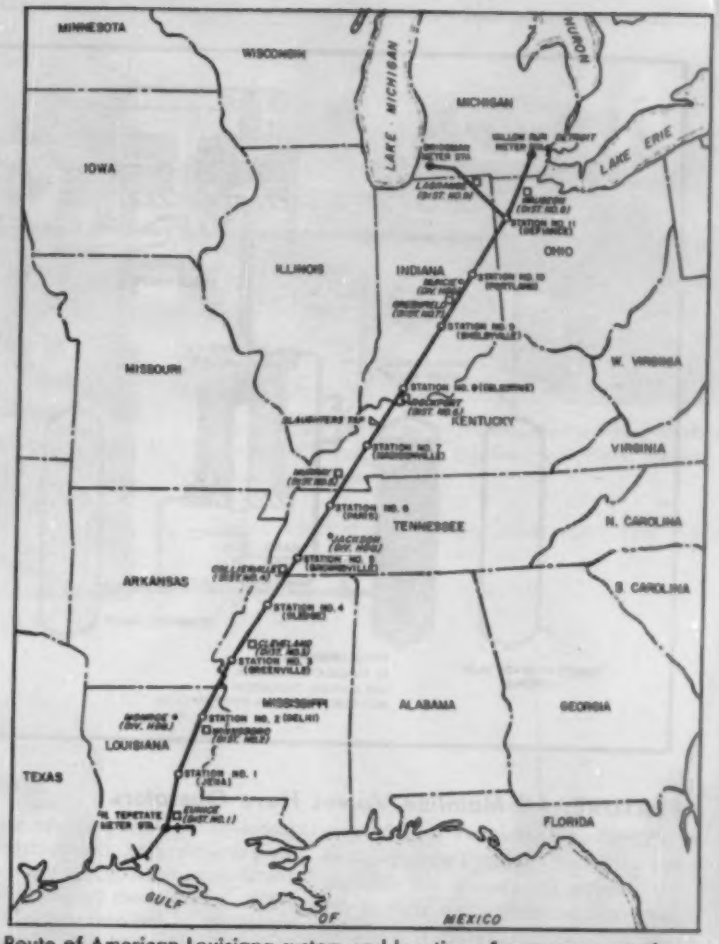
American Louisiana initially is receiving 250,000,000 cu ft per day in southwestern Louisiana from Superior Oil Company, Stanolind Oil and Gas Company, British-American Oil Producing Company, and Kerr-McKee Oil Industries, Inc. It receives 50,000,-000 cu ft per day from Texas Gas Transmission Corporation near Slaughters, Kentucky.

How It Was Built

The American Louisiana pipe line system crosses eight states and five major rivers between southern Louisiana and the terminus near Detroit, Michigan. The general route was chosen as being the most direct from the source of supply to the markets in Michigan and Wisconsin. The mainline consists principally of approximately 1000 miles of 30-in. and 60 miles of 24 and 26-in. pipe. A 22-in. line is being constructed from a point near Defiance, Ohio, to connect with the Michigan Wisconsin pipe line at Bridgman, Michigan, a distance of 122 miles.

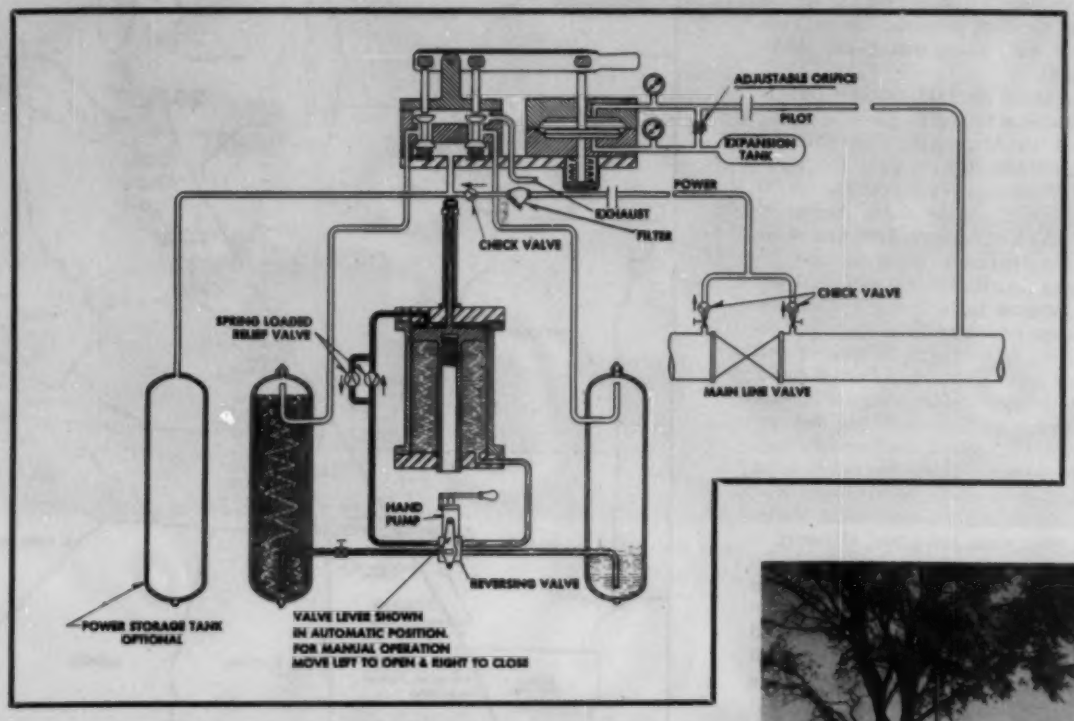
Major river crossings include dual 24-in. lines across the Red River in Louisiana, the Mississippi River separating the states of Arkansas and Mississippi, and the Ohio River between the states of Kentucky and Indiana. Single 30-in. line crossings were made on the Ouachita River in Louisiana and the Tennessee River (Kentucky Lake) in Kentucky.

Mainline valves are of the full opening type manufactured under ASA specifications. These valves are equipped with special transition pieces installed by the manufacturer. This step eliminates a heavy weld on the body of the valve, which would require stress relief in the field. The valves are spaced approximately 15 miles apart.



Route of American Louisiana system and location of compressor stations.

Lay barge, pontoon barges, tugs, and supply barge — equipped with office and crew quarters — at work on the twin 24-in. crossing of the Mississippi River. In background is dredge. More than $6,500,000 in equipment was used on this crossing.



FEATURE: ***All Mainline Valves Have Operators***

American Louisiana's 30-in. mainline valves are equipped with operators for opening and closing. As with any automatic machinery, the heart of the operator is in the controls. It is so contrived as to be sensitive to an excessive "declining" rate of change of pressure such as exists in an emergency.

Should pressure in the pipe line adjacent to the valve start decreasing at an excessive rate, the control senses the change and triggers the operator, which in turn closes the gate valve. The sensitivity of the control can be set to any pre-determined rate of change of pressure. On American Louisiana, the controls are set to close the valve if the pressure decreases at a rate exceeding 15 psi per minute.

Operators, with automatic valve controls, are used to actuate the mainline gate valves. The control mechanism that triggers the automatic closure of the valve is sensitive to excessive rates of changes of pressure and rapidly closes the valve in the event of a decrease in pressure in the pipe line. Valves can be closed in approximately 20 to 30 seconds.

All pipe used on the system was manufactured under the API specifications for high test steel line pipe. The installation, including field welds, fabricated assemblies, cased crossings, testings, etc., was performed in strict accordance with the new ASA code — B31.1-1955.

Testing

Field testing, including leak tests, after construction and before the line was placed into operation, was conducted in accordance with the requirements of the ASA code. Three mediums were used for testing: Water, air, and natural gas as required. Mobile compressor units mounted on flat bed trailers were used on the entire system where air or gas was the test medium.

The "Big Shove"

Landowners' objection to a flotation canal in southern Louisiana's marshland forced a unique laying operation. To overcome this objection, a ditch was dug with draglines mounted on marsh buggies. A "shove" station was set up on a high spot of ground. Here, single joints of concrete coated pipe were field jointed and shoved out into the marsh a distance of 12 miles. Empty 55-gal drums were wired to each joint to keep the pipe floating. A marsh buggy pulled the lead end to maintain the proper bend in the section. At seven miles from the shove station, the ditch changed direction 28 deg. A mile and a half farther, it bent again at approximately the same magnitude. After the section was completely shoved in, the drums were cut to allow the pipe to settle in the ditch.

Design of Line

Ford, Bacon & Davis, Inc., New York, engineers for American Louisiana Pipe Line Company, were given the task of designing the 1000-mile pipe line to carry 300,000,000 cu ft of gas daily, with an ultimate design of 550,000,000 cu ft per day. Designed entirely under the requirements of the ASA code, maximum throughput at minimum cost was obtained by use of 30-in. high-test steel operated at a pressure of 858 psig. Three compressor stations will carry the 300,000,000 cu ft daily, while 11 compressor stations

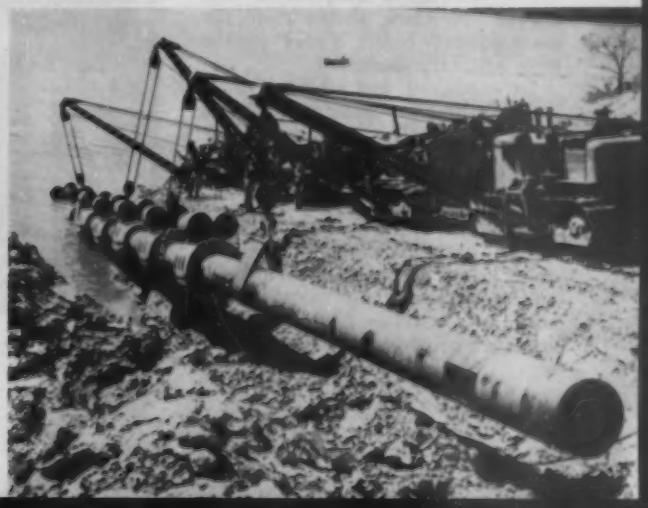
Backhoe cuts bank approach for crossing of Driftwood River near Edinburg, Indiana.

Near Eudora, Arkansas, track mounted welding machines are given a tow through the low, wet, delta country as firing line moves up.

Boring road crossing under rural road near Adrian Michigan.

Above — Welding the 30-in. line in piney woods of Louisiana. Below — Coating and wrapping crew at work near Chrisney, Indiana.

Crossing Ford Lake near Ypsilanti, Michigan, with 30-in. line, using river weights. Oil drums gave pipe enough buoyancy to prevent it from dragging on bottom of dredged pipe channel as it was pulled into place.



will be used for the ultimate delivery.

Station Design and Equipment

All compressor stations are designed to be self-contained; that is, the water, electric power, sewage, etc., are on the site. Station equipment is of the latest design reciprocating engines. Three stations make up the initial installation, each built with five 2000-hp engines.

Spaced approximately 250 miles apart on the 30-in. main line, they are located as follows: Station No. 3 — Greenville, Mississippi; Station No. 6 — Paris, Tennessee; Station No. 9 — Shelbyville, Indiana. Additional stations will be added as capacity of the line is increased.

Station sites were purchased, and pig traps and stubbed suction and discharge lines installed on the site as the main pipe line was built. One house for the superintendent is built on each of the three station sites. Stations were situated on paved highways near adjacent towns, thereby lessening the need for company housing.

The main units have hospital type silencers on both free air and exhaust. The stations have complete basements with a minimum of 6-ft, 6-in. head clearance under all piping. Pulsation dampening is installed in all suction and discharge bottles.

Power is purchased.

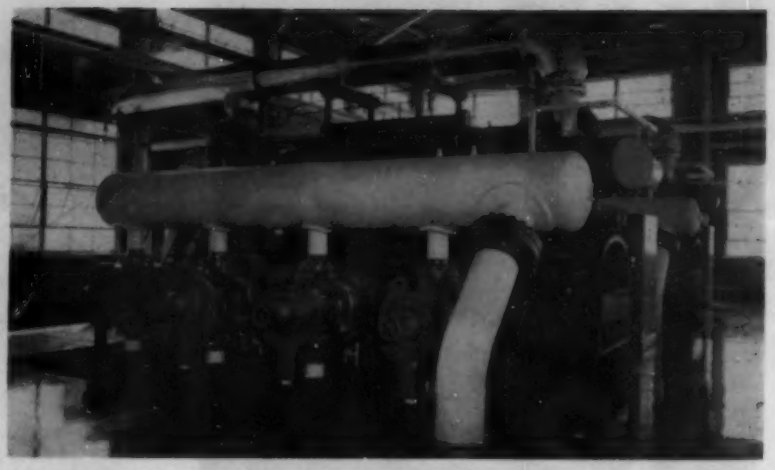
All stations, however, are equipped with a complete standby auxiliary unit ready to pick up the load automatically after a 20-second delay in power transmission. The valves for loading and unloading the engines are equipped with pneumatic operators and are controlled by push-button devices on the starting stand of each unit.

The emergency controls of the plant are operated by an "always on" system; in other words, any reduction in pressure in the control lines automatically will blow-down the yard piping and shut off the units.

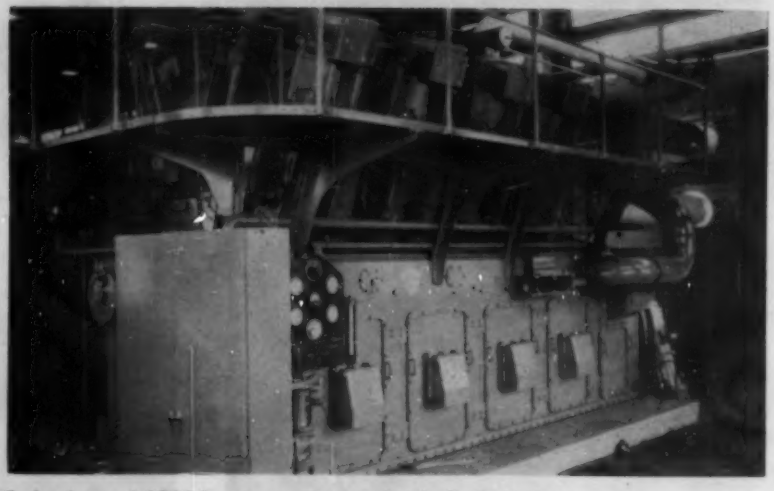
All the piping was designed under the ASA code and each station was tested hydrostatically to 1500 psi. Stations are designed for 1000-psi operating pressure. They are equipped with the latest type horizontal scrubbers, which, working in conjunction with scraper operations, should clean the gas adequately before it goes into the main units for transmission.

Self-contained, low pressure boilers (15 psi) heat the main building and meter building. The auxiliary building, office, warehouse, and garage buildings are heated by gas-fired unit heaters, which are considered more economical.

All stations are on 20 to 30-acre sites, with provision made for future expansion. Fuel gas for the engines is metered through separate runs for the main units only. Auxiliary fuel is measured through a positive displacement meter.

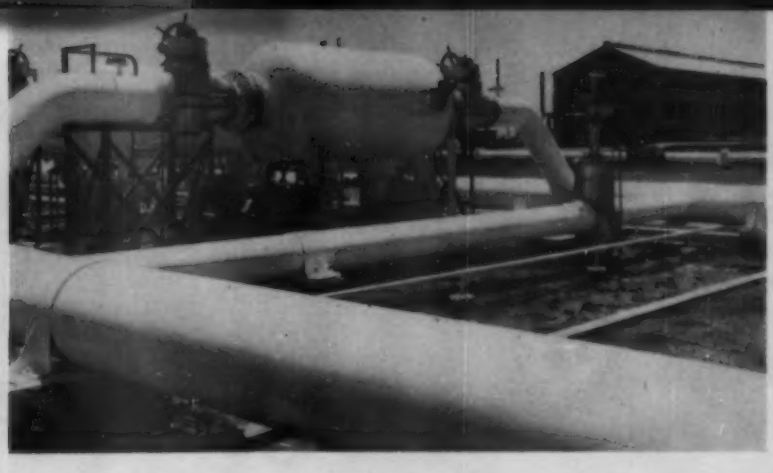


Interior of Shelbyville, Indiana, compressor station.



Turbocharged 2000-hp compressor engine in Paris station.

Operator makes check on 2000-hp compressor at Greenville, Mississippi, station.



Scrubbers and piping, Greenville, Mississippi, compressor station.

Fin-fan water cooler under construction at Paris compressor station.

Compressor Station Control System

Valve operators are installed on suction, discharge, and by-pass to each main unit. A solenoid is installed on the side of each of the operators to make contact when the valve is either open or closed. They are opened or closed by simply pushing a button on the control panel in the main engine room. The operators are opened or closed according to whichever button is pushed. The solenoid simply lights a lamp to show whether the valve is closed or open. In this manner, an engineer can put an engine on the line without having an oiler operate the valves in the valve yard. It is simple, dependable and a labor saver.

Another type of control provides complete evacuation of gas from suction and discharge lines in the station yard piping. An emergency blow-down system is installed in all stations. In this manner: emergency stands are at the entrance gate and at the air tanks. The system is an "always on" system — pressure is always on the pilot line. The plant would be shut down when the 1-in. valve in the emergency stand is opened. This evacuates the pressure in the line to the operators, which are located on the 26-in. suction, 26-in. discharge and the 10-in. blow-downs near the pig traps.

At the same time, the relief of pressure causes the mercoid switch to operate on each of the main units grounding the pulse generator and shutting the unit down.

Example: when the station is on the line, the 10-in. blow-downs are closed, the suction and discharge lines are open, and the units are operating. In an emergency the 1-in. valve is opened, which bleeds pressure from the pilot lines going to the operators on the suction and discharge lines, causing them to close, and making the two 10-in. blow-downs open.

This evacuates the gas in the suction and discharge lines going to the engines and at the same time the ignition on the engines are grounded out by the mercoid switch, which has been activated by the pressure evacuation in the pilot line, therefore the station goes down and the gas is evacuated from the main piping.

Fuel runs are jacketed for the jacket water to heat the gas, thus eliminating condensation during the summer months in the meter building.

Air supplies the force required for movement of oil to the main engine as well as to the scrubbers. Both eliminate the hazards of moving barrels around by hand. Cooling systems are of the closed type. Fin-fan construction of the latest design is installed to cool the jacket water as well as the lubricating oil. The fin-fans have louvers that are automatically actuated by air operators to cut off certain sections when not needed.

All units have full-flow filters for filtering the oil. Jacket water is filtered through a partial flow filter in the auxiliary building. This filter takes care of approximately 20 per cent of the total system water per day. All main units have individual water pumps installed on the unit similar to an automobile. This eliminates the use of pump pits and additional equipment.

The main units have drain lines to drain lubricating oil from the crankcase to an oil storage tank in the basement when the unit is to be worked on. The oil is filtered going to the tank as well as when it comes back to the unit, which eliminates dirt and contamination from the lubricating oil.

Each compressor station has a fully equipped machine shop.

Operations

General offices of American Louisiana Pipe Line Company are in Detroit, Michigan. Division offices for the pipe line and compressor departments are at Muncie, Indiana; Jackson, Tennessee, and Monroe, Louisiana. The pipe line is divided into three divisions, each of which has three districts, making a total of nine in the system under three division superintendents.

The compressor department is now under the supervision of one field superintendent, but later when 11 stations are built, it will be divided into two divisions.

Pipe line district headquarters are located between the compressor statons where feasible, and no two departments are in the same area. This makes the line quite easy to operate for maintenance and emergency calls.

Maintenance will be handled in each of the compressor stations by their own local crew. On the pipe line, maintenance will be handled by the district pipe line crews, which average about 136 miles of pipe line per district. The central district of each of the three in the division has heavy equipment such as big 210-hp trucks, track-type tractors, back-hoes for repair work and emergency maintenance.

Pipe and casing is stored at each of

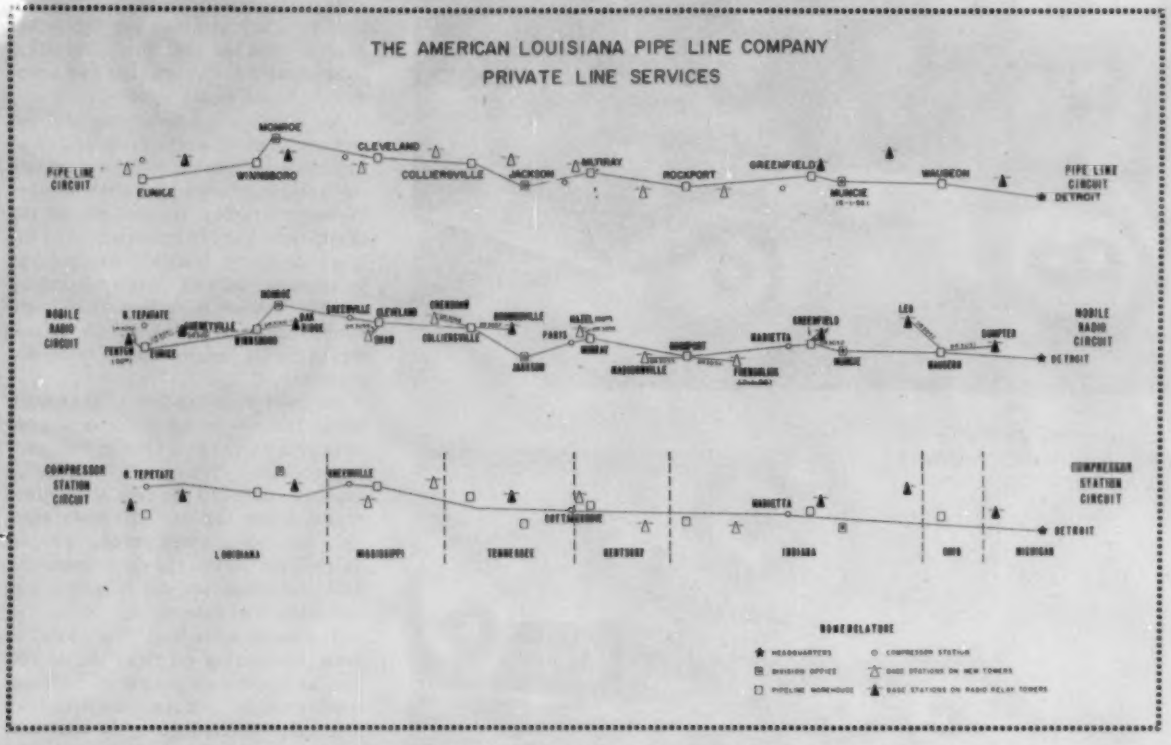


Diagram shows how three leased full-period circuits are used in the company's communications system.

the nine pipe line districts. All high-pressure welding will be done by the pipe line department for compressor and measuring as well as the pipe line departments.

Sales points are presently authorized at Willow Run, Michigan, and Bridgman, Michigan.

Communications System

To provide for day-to-day communications along the pipe line, as well as to be prepared for emergencies, American Louisiana is leasing a three-circuit communication network from the Bell System. Two of these circuits provide regular full period telephone service. One is a full period telephone circuit that connects all pipe line warehouses and pipe line division offices with Detroit headquarters; one is a full period telephone circuit that connects all compressor stations and master purchase station with Detroit headquarters; the third one is a full period mobile radio circuit. These circuits will be available to and used by all departments of American Louisiana.

The compressor circuit is used for the hourly flow and pressure readings from each of the compressor stations and the Tepetate master measuring station. This circuit will be used by the gas dispatcher in Detroit. The compressor stations are equipped with telephones in the auxiliary building and the office, both of which are connected to an explosion-proof horn in the main building. A telephone also is provided for the superintendent's home. This insures complete coverage at all times. This circuit also is equipped with dial signalling from any point, with an individual code for each station and a master code that connects all stations.

At each pipe line warehouse, three telephones have been installed. Switches permit these telephone instruments to be used on any circuit. All circuits are equipped for dial signalling from any point, with an individual station code and a master code that is used to call all stations at once.

The third circuit is a mobile radio circuit with unusual features. By using a combination of mobile radio units, base radio stations along the pipe line route, and interconnecting routes, the third circuit becomes a more flexible tool. A driver in the maintenance territories of his warehouse can talk to the warehouse without using the backbone telephone circuit. Yet, he can be connected through the warehouse or the backbone circuit to any other point on the pipe line when necessary. The mobile radio backbone circuit connects all offices on the pipe line. Thus, it also can be used to supplement either of the other telephone circuits in time of emergency.

All telephone instruments that can be used on the mobile radio circuit have been equipped with a push-to-talk button, which is used to activate the transmitter at the base stations. The pipe line warehouses will be the control point for one or two base radio stations. To contact an individual in a vehicle, a call will be placed to the warehouse that controls the radio base station nearest the vehicle, the warehouse will switch the call to the base station, then the party placing the call will use the push-to-talk button and transact his business.

Field Facilities

American Louisiana Pipe Line Company initially is scheduled to take gas from five sources: The British-American Oil Producing Company, Kerr-McGee Oil Industries, Inc., Stanolind Oil and Gas Company, Superior Oil Company, and Texas Gas Transmission Corporation.

At Cameron, Louisiana, just a few miles from the Gulf of Mexico, American Louisiana has a measuring station to take gas from Stanolind in the Cameron gas field. This gas is moved northeast through approximately 37 miles of 16-in. line. At that point, the 16-in. line joins a 26-in. line carrying gas purchased from Superior Oil Company at American Louisiana's Lowry meter station. Twelve miles north of Lowry, a 12-in. lateral with gas from Stanolind's South Jennings field ties into the 26-in. line.

This commingled stream travels

Air, Gas, and Water Used in Line Testing

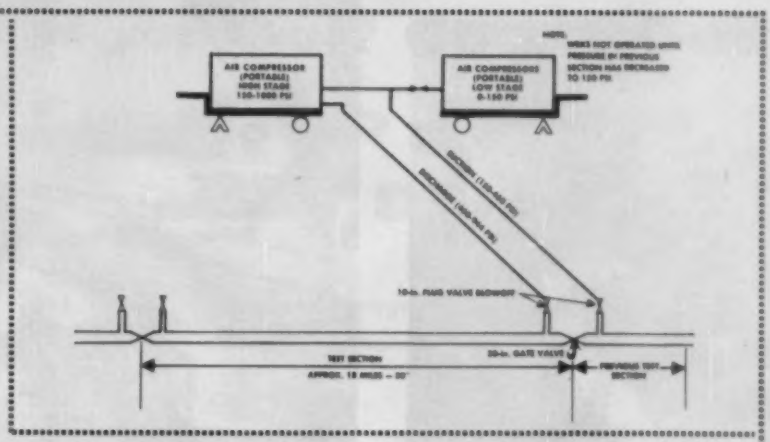
Hydrostatic test was conducted in a conventional manner and using test pressures of a minimum of 944 psi on American Louisiana's 30-in. line as required by the ASA pipe line code.

Air test was conducted from valve to valve (sections of approximately 18 miles each) using compressors arranged in series. Two low stage units in parallel were used to feed into each high stage compressor. Essentially, the piping arrangement is the same as a compressor station, where the mainline valve serves as a block gate and the blow-off valves as side gates.

In testing the first section with air, the air must be taken from atmospheric pressure to test pressure and this test pressure is held for the prescribed time. To test the next section, the mainline gate valve was opened and the pressure in the two sections was equalized. This valve was then closed and the high stage compressor was operated alone until it reduced the pressure in the tested section to 150 psi. At this point the low stage was cut in and operated in series with the high stage, taking air from atmosphere, until the section being tested reached test pressure.

Gas for testing was taken at Lowry, Louisiana, at a pressure of 1050 psi or at the Slaughters, Kentucky, taps at a pressure of 800 psi. After pressuring the first section to be tested to test pressure by use of the pressure at which gas was delivered and, if necessary, by use of the high stage unit, the same procedure was followed as with air in testing subsequent sections, except that only the high stage was used, since after a section was tested and the mainline valve opened to the next section, this section's pressure could be raised to operating pressure from the source of supply. The testing rate with gas was about one mile per hour.

In performing the water tests, a displacement pig was placed in the line at the point where water was to be injected. Water was then injected behind the pig until the entire section was filled with water and thus purged of air. Pressure of the entire section was then brought to test pressure and held there for the prescribed time. After the line was filled with water, it was determined that it was necessary to inject about 1 per cent more water to take care of the compressibility of water and the expansion of the pipe in bringing this section to test pressure.


AIR COMPRESSOR (PORTABLE) HIGH STAGE 150-1000 PSI
AIR COMPRESSORS (PORTABLE) LOW STAGE 0-150 PSI
10-in. PLUG VALVE BLOWOFF
30-in. GATE VALVE
TEST SECTION
APPROX. 18 MILES -- 30"
PREVIOUS TEST SECTION

Typical diagram of air test set-up.

Typical testing package of two low stage compressors and one high stage compressor.

north for approximately 24 miles to the North Tepetate master measuring station. There, a 24-in. line tees in from the east, and a 10-in. line tees in from the west. This 24-in. line carries gas from the Stanolind Savoy, Bayou Mallet, and Lewisburg fields east of Eunice, Louisiana.

Gas also purchased from Stanolind at the North and South Elton, Iowa, and Welsh fields west of Eunice join the main stream through the 10-in. lateral. This gas, however, is gathered by Texas Gas Transmission Corporation for American Louisiana. At the North Tepetate meter station, the initial pressure of from 900 to 1050 psi is reduced to the normal operating pressure of the pipe line as it enters the 30-in. line for transportation to Detroit.

American Louisiana is measuring all gas through master meter stations at the various fields. At the Cameron measuring station, the gas is gathered from the various wells by Stanolind, and after being dehydrated, is measured through a 12-in. orifice meter run. This 12-in. meter run is in parallel with a 12-in. bypass line, so installed that it can be easily converted in the future to a second orifice meter run should the need arise.

Near Lake Arthur, Louisiana, gas gathered along the Gulf Coast and transported to American Louisiana through a 24-in. line by Superior Oil Company is measured at the Lowry measuring station. Gas enters the station through a 24-in. inlet line.

The inlet line enters the building through a trench running along the west end of the building. This trench houses the upstream meter run header, a 24-in. prefabricated extruded header assembly. The downstream meter run header, a 26-in. extruded header, is in a trench along the east side of the building.

Three 12-in. lines rising from the headers are topped by 12-in. plug valves. Twelve-inch meter runs, each containing a flanged senior orifice fitting, extend between these risers, bolted between flanged ells, each fab-

On the "big shove" in South Louisiana some 12 miles of line was floated into place. Barrels provide buoyancy. These two photographs show "Operation Shove" underway outside Cameron, Louisiana.

ricated out of two weldneck flanges and one weld ell. These meter runs are fabricated in accordance with AGA Gas Measurement Committee Report Number 3.

Flanged type straightening vanes, consisting of 19 tubes each, in accordance with the latest AGA specifications, are fastened upstream of the orifice fitting.

Corrosion Protection of Line

Two basic types of coating material were applied to the pipe line system. Except for a few sections requiring special double coating, regular coating was applied over the ditch.

Plasticized, modified, and hot line coal tar enamel were the major types of coating used. The class of enamel used on a given section of pipe line depended on weather conditions at time of application and temperature of gas to be transported.

Conventional procedures were followed in applying coal tar enamel. Cleaning machines cleaned the pipe applied coal tar primer. A single coat of enamel was followed with a wrapping of coal-tar-saturated, glass-reinforced asbestos felt.

The second type of coating material is polyethylene tape, which was applied to a 10-mile section of 30-in. pipe and has been selected for application on 122 miles of 22-in. pipe. Cleaning machines cleaned the 10-mile section. The tape and an asbestos felt outerwrap was spirally wrapped on the section by a specially built machine. This procedure will be followed for the tape application on the 22-in. line.

Following the coating and wrapping crew, the coated pipe was jeeped to locate coating flaws. Coating repairs were completed and jeeped again before pipe was lowered in the trench.

Damaged coating resulting from lowering in backfill operations was located by a Pearson holiday detector, then uncovered and repaired.

Other facilities installed on the pipe line during construction to aid the corrosion control program include pipe insulators and casing seals on all cased crossings. Also, test leads were installed at designated points along the pipe line to facilitate corrosion testing.

Installation of approximately 40 rectifier units is planned for the cathodic protection of the pipe line system and will complete the initial corrosion control program. * * *

Left — Scrubbers and blow-down, Lowry, Louisiana, where Superior Oil Company delivers gas to American Louisiana. Below — Interior of Lowry meter station.

MICHIGAN WISCONSIN

New Gulf Coast Gas Supply to Relieve Pressing Demand

$11,500,000 expansion program underway will enable company to deliver additional 100,000,000 cu ft daily

MICHIGAN Wisconsin Pipe Line Company, a wholly-owned subsidiary of American Natural Gas Company, was organized in 1945 as a long distance natural gas pipe line company to transport gas across a 10-state area and, currently, supplies more than 110 billion cu ft of gas a year to 16 utility companies in the states of Michigan, Wisconsin, Iowa, and Missouri. These companies, in turn, sell gas in local distribution. The two largest customers of Michigan Wisconsin are Michigan Consolidated and Milwaukee Gas Light.

The pipe line has invested in property, plant, and equipment more than $127,000,000. This figure includes expansion of pipe line facilities now being constructed principally in the states of Illinois and Wisconsin. Construction of some lateral lines in Iowa and Missouri also are included in the program.

Expansion Underway

These additions to the Michigan Wisconsin system will be made at an estimated cost of $11,500,000. All construction except 23 miles of 24-in. looping either has been or will be completed in 1956. This 23 miles will be completed in 1957. This construction program includues a total looping of 235.8 miles of main and lateral lines; laying 16.1 miles of larger diameter lateral line to replace existing laterals of smaller diameter; addition of three compressor engines totaling 3400 hp to the system, one at compressor Station 10 at Sandwich, Illinois, and two at Station Wisconsin "A" at Woodstock, Illinois. Practically all of this expansion is designed to increase the supply of natural gas to Wisconsin markets, and will increase this supply by approximately 100 per cent. This expansion of the pipe line system will permit the company to deliver an additional 36.5 billion cu ft of natural gas annually that it will receive from its affiliate, American Louisiana Pipe Line Company. American Louisiana brings natural gas to the Great Lakes region from the rich fields on the Louisiana-Gulf Coast, while Michigan Wisconsin transports its natural gas from the vast Hugoton field that covers areas in Kansas, Oklahoma, and Texas.

Where M-W Operates

Michigan Wisconsin operates 1592 miles of transmission line, of which 796 miles is 24.-in. The 24-in. pipe is laid between Edgar G. Hill field station in Hansford County, Texas, through a seven-state area to a point known as "Wisconsin Junction" near Sandwich, Illinois.

At "Wisconsin Junction" the line divides into two 22-in. lines, one going up the east coast of Lake Michigan to the storage fields near Big Rapids, Michigan, and the other extending into Wisconsin to serve the Wisconsin markets. As the line goes north into Wisconsin, and as additional Wisconsin markets are served, the line tapers down from 22-in. to 18, 14, 12, 10, 8, 6, and 4-in. lines.

Compressor Stations

The compressor horsepower required to operate Michigan Wisconsin's pipe line system totals 140,800, with the largest of 15 stations having 36,000-hp. This is the Edgar G. Hill field station, where the company takes its gas supply from the Phillips Petroleum Company at about 200 psi and compresses it to 975 psi in preparation for transmission through the pipe line system.

100 Per Cent Load

Michigan Wisconsin's main line is designed to operate at a 100 per cent load factor — a fact largely attributed to the use of underground gas storage fields in Central Michigan. Here, in reactivated natural gas fields, gas is stored in the summer months and withdrawn in the cold winter months to meet peak customer demands.

Four separate fields operated for this purpose cover approximately 39,000 acres and are capable of storing some 44 billion cu ft of gas. The fields contain 290 wells, which are drilled in strata known as Michigan Stray, to an average depth of 1300 ft. Through these wells the gas is placed in and withdrawn from storage.

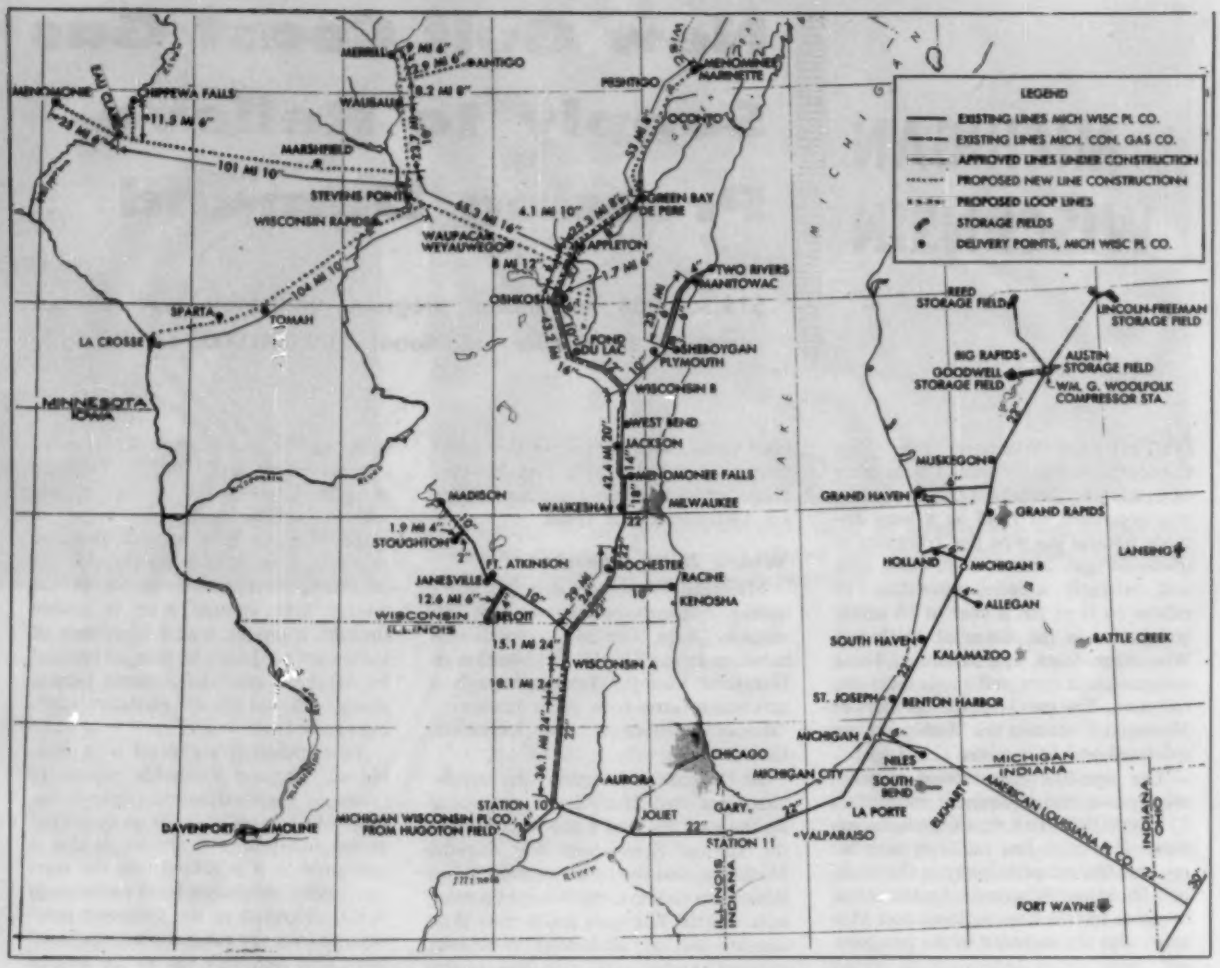
To maintain the required pressure and flow rates, gas flowing through the 20,280-hp compressor station in the Austin field storage area is routed through a unique manifold system of valves up to 24-in. in size, connected by overhead and underground piping, along with a series of regulators varying in size from 4 to 12-in.

This station is equipped with double suction and discharge piping to facilitate gas distribution through the manifold system. All gas is measured at the manifold as it arrives. It also is measured as it is routed into the storage fields, withdrawn from the storage fields, delivered to the customer markets, and for the company's operational use. This requires up to 26 orifice meters and temperature recorders. On a peak day last winter, a total of 673,000,000 cu ft was delivered to customer markets from storage.

Microwave

When Michigan Wisconsin began operations late in October, 1949, communication along the pipe line was provided by simple leased wire circuit connecting the general office with four key field installations. As the pipe line system grew from an initial three compressor station operation to one of 15 compressor stations spread over a 10-state area and covering nearly 1600 miles, the company switched from the leased line communication to a modern microwave system.

Portions of the Michigan Wisconsin microwave system were in service prior to October 1, 1954. At this time, the company discontinued use of the leased line facilities and made complete use of its completed microwave system covering 1540 path miles. Actual circuit miles, however, total almost 10,000. This 2000 megacycles microwave system, combined with an extensive VHF mobile radio system, was in-



System in Wisconsin and Michigan showing lines under construction and proposed loops.

stalled by the Federal Telephone and Radio Corporation.

Sixty relay station towers dot the pipe line route and are spaced distances ranging from 7 to 38 miles apart, depending upon the natural terrain and allowances for operational efficiency factors. All mainline stations are equipped with emergency power generators and standby electronic equipment. Eleven company radio technicians are kept busy maintaining radio equipment, which employs more than 11,500 tubes, and servicing 95 mobile units including five airplane sets and four "walkie-talkie" pack sets.

Meeting Market Demands

Michigan Wisconsin's plans for expansion of current markets include a proposal now before the Federal Power Commission (in Docket G-9850) to deliver gas to 10 distribution companies in Wisconsin, who serve 41 communities in the state and one community in Menominee, Michigan. These communities at present time are without the use of natural gas.

Upon FPC approval, Michigan Wisconsin will build 424 miles of pipe line extensions and 48 miles of main line loops in Wisconsin. One new 6000-hp station, designated as Wisconsin "B", also will be added to the system. An additional total of 6600 compressor horsepower will be added to existing stations near Sandwich, Illinois, and Bridgman and Hamilton, Michigan.

In allocating American Louisiana's initial 300,000,000 cu ft of natural gas per day, the FPC set aside 80,000,000 cu ft per day to serve new market areas as they are approved. Approximately 62,000,000 cu ft of this gas, which is still available, is more than double the amount needed to meet the requirements of the new market areas in Wisconsin.

In accordance with FPC approval in Docket G-2327, Michigan Wisconsin soon will take an additional gas supply into its system from its affiliate, American Louisiana Pipe Line Company. Of the 100,000,000 cu ft of gas supply requested by Michigan Wisconsin in its application, 85,000,000 cu ft has been granted with allocation to specific markets defined. The balance of 15,000,000 cu ft also is being received by Michigan Wisconsin pending allocation to specific markets by future FPC action.

The additional gas purchased by Michigan Wisconsin will be delivered by American Louisiana through a 122-mile, 22-in. tie line, now under construction. This tie line will stem from American Louisiana's 30-in. line near Defiance, Ohio, and connect with Michigan Wisconsin's pipe line near Bridgman, Michigan.

Michigan Wisconsin has been in dire need of this additional gas since its market demand has far exceeded the available supply. Because of this shortage, restrictions on the use of gas for space heating and industrial purposes have necessarily been in effect in the areas served by Michigan Wisconsin. The new gas supply from the Gulf Coast of Louisiana will increase Michigan Wisconsin's present daily deliverability of 303,000,000 cu ft by 33 per cent and will permit removal of all existing restrictions on service in the near future.

EXCLUSIVE

A 250-ft spread—cleaner, single cradle, wrapper, lowering-in, and backfill.

P 615.33

On a 122-mile, 22-in. line connecting American Louisiana and Michigan Wisconsin systems . . .

Polyethylene Plastic Tape Gets First Major Test

Donald M. Taylor
Editor, Gulf Coast

POLYETHYLENE plastic tape finally got its first large-scale application on a major cross-country pipe line. The entire length of the 122-mile, 22-in. line that connects the newly constructed American Louisiana system with the Michigan Wisconsin system was coated with polyethylene tape and an outer wrap of pipe line felt.

This large-scale use of polyethylene plastic came as the result of American Louisiana's successful application on a 10-mile section of its 30-in. mainline last spring. The test proved the coating and lowering-in operations could be combined and equipment and labor held to a minimum. This provided a tangible savings that the contractor could pass on to the company. The decrease in laying cost was sufficient to offset the higher cost of polyethylene plastic tape, making it competitive with other coatings.

Aside from the ease of application, the test produced excellent holiday records. The holiday detector run behind the coating machine "jeeped" on an average of once every 800 ft, and the Pearson detector, run after the pipe was backfilled, picked up only six holidays in the 10-mile stretch.

Tape. On the 22-in. line running from Defiance, Ohio, to Bridgman, Michigan, the line was wrapped with Polyken's No. 900 Protective Tape Coating 15 in. wide and 800 ft per roll. The tape is 12 mils thick — 8 mils of polyethylene film and 4 mils of inert synthetic adhesive. On river crossings and densely populated areas a 20-mil tape was used and 15 mils of this thickness was film. The 12-mil tape costs about $7 per square in large quantities and 64.8 squares will cover 1000 ft of 22-in. pipe including a normal wastage of about 5 per cent.

Wrapping. No primer was used — the pipe was simply cleaned and the tape applied at atmospheric temperatures. (The tape may be applied at subfreezing temperatures, say the developers.) The tape was spiral wrapped onto the pipe by a specially designed power-operated machine that resembles conventional wrapping equipment. The pressure sensitive tape achieves ultimate bond strength after it goes on the pipe. Cold application makes it possible to lower the pipe directly into the ditch.

Outer wrap. The same wrapping machine covered the polyethylene plastic wrap with standard 8-lb saturated asbestos felt. This gives the coating mechanical protection during backfill. There is no bond between the tape and the felt; the latter is held in place by tension alone. At the end of each roll of felt, strips of adhesive tape were wrapped around the pipe to hold it in place.

Stub rolls. The stub rolls of tape

were passed on to the tie-in gang every night. Only two men were required to hand wrap all tie-ins.

Holidays. The welds were thoroughly cleaned and buckshot chipped from the pipe ahead of the cleaning machine, helping to keep holidays at a minimum. For instance, on one spread the holiday detector run after the wrapping machine "jeeped" only 22 times in 23 miles. These holidays were postage stamp patched with the tape, and the Pearson detector run after the pipe was backfilled picked up only two holidays in this same section.

Equipment used in coating and lowering-in. Two contractors — Houston Contracting Company and H. C. Price Company — laid from either end of the line toward the middle of the 122-mile stretch. Both used a similar line-up of equipment and labor. Houston Contracting used one tractor cradling for the cleaning machine, one tractor cradling for the wrapping machine, and one "catch-off" tractor. A sled hooked onto the tractor at the wrapping machine carried a half-day's supply of tape and felt (enough for one mile of line).

Price used an additional "catch-off" tractor because of the hilly terrain and pete bogs on the western end of the line.

Crews. Here is a breakdown of the combined coating and lowering-in gang on Houston Contracting's spread:

1 foreman,
1 truck driver.

Cleaning

1 side-boom tractor operator,
1 swamper,
2 skid men,
1 cleaning machine operator.

Coating

1 side-boom tractor operator,
1 swamper,
1 coating machine operator,
1 pole man (for coating machine).
2 tape latchers,
2 material handlers (to carry rolls of tape and felt from the sled to the coating machine),
1 material man on sled,
1 "jeep" man (for holiday detector).

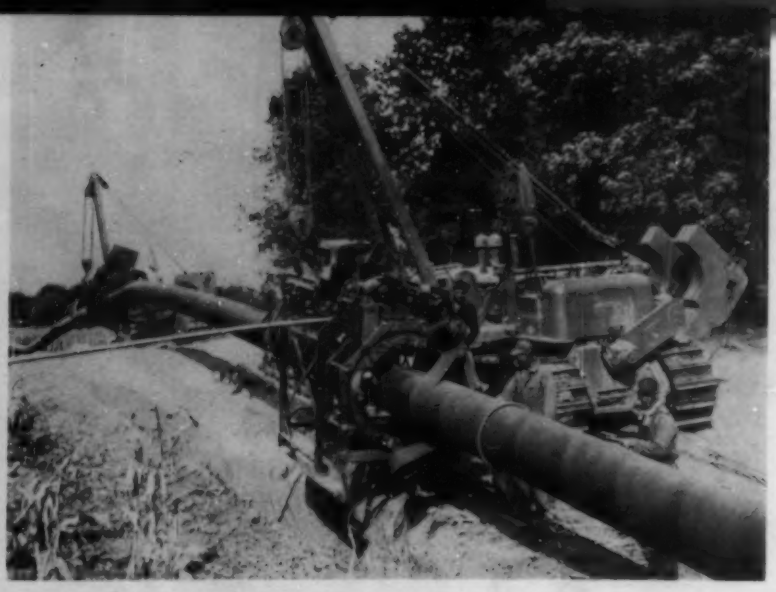
Lowering-in

1 side-boom tractor operator,
2 swampers to handle skids and make patches.

20 — TOTAL

Price used an additional three men on the extra catch-off tractor.

Clean-up and backfill. One of the most unusual sights for a visiting pipeliner was the backfilling equipment operating only 500 ft or so behind the wrapping machine. As a matter of fact, the distance from the firing line welders to backfill was often less than a mile. This reduced the amount of open ditch, and, in turn, minimized the hazard of wet weather.



Close-up of the cleaning and wrapping operations.

Completed footage — backfilled with 100-ft of wrapping.

Features. Briefly, the features of the coating are:

- It is cold applied and gains ultimate bond strength after application.
- It can be cradled directly into the ditch instead of onto skids for cooling.
- There is no spillage of coating materials.
- Holidays are few and easily patched in a matter of seconds.
- Small gangs can coat the pipe at high speed.
- The coating material comes in light packages, is easily handled by hand, and is ever-ready for application.
- The electrical and water barrier characteristics are excellent. At the same time, it must be pointed out, that the coating has a seven years' history, and this is brief according to many pipe line companies. ★ ★

How To Use

Bonded-Wire Strain Gages

For Determining Secondary Stresses in Pipe Lines

D. L. Shipp, G. M. McClure, and H. J. Grover
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EXCLUSIVE

DURING the past two years, the American Gas Association has sponsored research at Battelle Institute to investigate the design of pipe line reinforced branch connections. This project was under the guidance of the AGA Supervisory Committee for Girth Welding and Branch Connection Research. The main phase of the work was completed in 1955.

During 1956, the research is being continued to investigate a related problem in pipe line design — the secondary stresses that occur at branch connections and at other points in a line. The problem of secondary stresses may be stated as follows:

> The operating pressures in a pipe line are based upon the nominal circumferential stress produced in the pipe by internal pressure. In addition to this stress, other stresses known as secondary stresses are present. They are caused by such things as temperature changes in the line and external loads or forces from various sources imposed on the pipe.
>
> Some of the secondary stresses are well enough defined to be calculated and taken into account in the design of a line. Others, however, are not well defined and in some cases cannot be "designed out" of a line with assurance. For this reason, further knowledge of secondary stresses at critical locations in pipe lines is considered important for a complete picture of the total stress that can occur in a line.

Editor's Note: The Pipeline Engineer is pleased to publish as a service to the pipe line industry this report on the use of bonded-wire strain gages for determining secondary stresses in pipe lines. This article, to be published in two sections — in this issue and the December issue — has been made available through the courtesy of the American Gas Association, for whom this research was performed.

The AGA Supervisory Committee is soliciting individual company cooperation in obtaining information on secondary stresses. Specifically, the companies are being asked to get specific data on secondary stresses at critical locations in their lines as the opportunity arises. Provisions have been made with Battelle Institute for furnishing consulting help at any time in doing this and for compiling and interpreting the data that are obtained.

The purpose of this report is to point out some of the sources of secondary stresses and some ways in which they can be determined in a line, and, in particular to discuss the use of bonded-wire strain gages to determine stresses in buried lines.

The report is divided into two main parts. Part I points out some prominent sources of secondary stresses in buried lines and discusses their relative importance.

Part II contains a discussion and suggestions on the use of bonded-wire strain gages in determining the magnitudes of secondary stresses in a buried line. Neither part of the report is intended to be a complete treatise on its subject. It is the intent to cover only the more important aspects of the problem at hand and to make reference to other publications for more detailed discussions.

All of Part I and two sections of Part II — selection of the proper types of gages and techniques for bonding strain gages — are presented in this issue. The remainder of Part II will be published in the December issue of *The Pipeline Engineer*.

Part I.
Discussion of Secondary Stresses

The term "secondary stress" is defined in the B31.1 Code for Gas Transmission and Distribution Piping Systems as "stress created in the pipe wall by loads other than by internal fluid pressure." For the purpose of this report the definition might be modified slightly to read "stress created in the pipe wall above that produced by internal pressure as calculated by the Barlow formula." In this way, some of the rather high secondary stresses that are actually a function of internal pressure are included within the definition.

In the following discussion, only static stresses in a line are considered. Vibration and alternating stresses are a separate problem and are not considered within the scope of the present discussion.

Sources of Secondary Stresses

Secondary stresses are produced by a number of things in a pipe line. The basic causes are generally internal pressure,

temperature change, or some type of external force on the line.

For the purposes of discussion, secondary stresses can be classified in several different ways. A general classification divides them into two main categories:

1. Stresses induced in a line during construction,
2. Stresses that occur later in the life of a line from changing temperatures, pressures, or external load.

Another more detailed system of classification lists some of the more prominent secondary stresses according to the "type" of stress and primary cause:

A. Circumferential stresses from

   1. *Earth loads,*
   2. *Impact loads (such as from traffic),*
   3. *Out-of-roundness of the pipe,*
   4. *Local flat spots and dents.*

B. Longitudinal stresses from

   1. *Bending and slack introduced during construction,*
   2. *Bending in unsupported and partially supported spans or from earth movement or settlement,*
   3. *Temperature changes from the temperature at construction.*

C. Torsional stresses from

   1. *Thermal or other forces at double bends and offsets such as might occur near overhead river crossings.*

D. Combinations of A, B, and C above.

All of the circumferential stresses listed above involve bending of the pipe wall in the circumferential direction. As long as the pipe remains round, only the nominal internal pressure stress exists; if, however, the cross section is distorted out of round or dented, localized bending stresses set up in the wall can become quite high, with relatively small distortion of the wall.

Backfill and traffic loads are external forces which distort the whole cross section out of round. Their effect is partially counteracted by internal pressure tending to keep the section round. A good discussion of secondary stress from this type of internal load has been prepared by Professor Spangler.[1] *

In the case of initial out-of-roundness or dents, the secondary stress is set up with the introduction of internal pressure, which pushes the pipe wall back toward the original curvature. A discussion of these stresses is given by J. Lodge and G. K. Manning.[2]

The longitudinal and torsionial secondary stresses listed above are produced mainly by temperature expansion and contraction, or by earth movement or settling causing axial or bending forces at some location in the line. These actions are most likely to produce high secondary stress at some "discontinuity" in the line such as a branch connection, an anchor, a bend, or a span.

In the case of above-ground piping, the stresses from these causes can be fairly readily calculated because the end restraints are usually known. In buried piping, however, the restraint against longitudinal expansion of the pipe is provided by friction between the pipe and the earth, which can vary over quite wide limits and is usually not known with much accuracy. For this reason it is considered desirable to obtain actual measurements in some buried lines of the forces and stresses at critical locations. Discussions of some of the longitudinal secondary stresses in pipe lines are given in References 3, 4, 5, and 6.

*References are listed at the end of the report.

Measurement of Secondary Stresses

There are many ways in which stresses in a structure can be determined. Theoretical calculations can be employed and are sufficient when all the loads and the restraints on the structure are known and when the stresses desired are not detailed stresses. In other words, in calculating stresses in a structure there must be assurance that the stress is constant over some known length or, if stress gradients are known to exist, the nature of the change must be known if the calculations are to be accurate.

In cases where there is not sufficient information on the loading conditions or stress gradients in a structure to make accurate theoretical calculations, then experimental measurements can be used to determine the stresses. There are many devices that can be used in experimental determination of stress. These can be generally divided into three classes—mechanical, optical, and electrical—and further subdivided in several different ways. Most of the devices involve a determination of strain in the structure, from which the stresses are calculated with knowledge of the stress-strain relationships for the material involved.**

Most of the mechanical and optical strain gages that are available require that the operator have direct access to the gage. For the problem at hand, that of determining secondary stresses in pipe lines, it is usually desirable that a remote type of gage be chosen. For this reason, some type of electrical gage is the most feasible. One of the most common and versatile electrical strain gages is the bonded-wire resistance strain gage. As the name implies, this gage indicates strain by the change in resistance of a length of wire in the gage that is bonded or cemented to the structure under investigation.

Part II of this report discusses in some detail the uses of bonded-wire strain gages. The present section points out some of the important factors that must be kept in mind in planning and making strain measurements in a pipe line and illustrates some typical gage arrangements.

Each job of measuring strains in a pipe line should be considered as an individual problem; however, the general steps that need to be followed can be summarized as follows:

1. **Statement of the problem and the objectives and detailed planning of the work,**
2. **Selection of specific strain-gage locations,**
3. **Application of gages,**
4. **Taking the readings of gages and other data essential to analyzing the problem,**
5. **Analysis of the gage readings and other data.**

Of course the first step, that of planning the measurements completely and in detail before actual work begins, is of primary importance. All of the steps listed above must be considered, so that as many as possible of the problems that might arise can be anticipated.

In the initial planning, the objective of the work is the first consideration; that is, what are the types of strains and stresses desired to be measured, and by what types of loads on the line are they produced. These consideraitons in turn define the gage locations, the frequency of the readings of the gages, and what type of other data should be obtained.

Where to locate gages. In order to illustrate some typical strain-gage locations, let us assume four specific cases in

**A complete treatise on experimental methods of determining strains and the many other aspects of experimental stress analysis can be found in Reference 7.

FIG. 1 Typical strain-gage arrangement in pipe.

which it is desired to measure the following secondary stresses. In all of these, it is presumed that the secondary stress will be superimposed on stresses from internal pressure.

1. A straight axial or longitudinal stress in the lines,
2. A bending stress,
3. A torsional stress,
4. Stresses in a fitting or a branch connection where the direction of the maximum principal stress in unknown.

The first thing to consider in picking specific gage positions is the distribution of stresses in the area under surveillance, namely, the location in which the maximum stress is likely to occur and the direction of the maximum stress. The number of gages that should be used, their positions, and their directions can then be decided upon with assurance that they will indicate the highest stresses in the line. In almost all cases in measurements on a pipe line, we are concerned with the biaxial stress field, that is, stresses in two directions on the outside or inside surface of the pipe or fitting involved.

In the case of a **straight axial or longitudinal secondary stress** in the line, the direction of the maximum stress will be either in the longitudinal or circumferential direction depending on the magnitude of the longitudinal force in the line. In either case, a single pair of gages, one applied in the longitudinal direction and one applied in the circumferential direction, is sufficient to determine the stress conditions.

When it is suspected that **longitudinal bending** might exist in the pipe, the secondary stress produced by the bending will vary around the circumference, being tension on the outside of the bend and compression on the inside of the bend. To get a good picture of the stresses under these conditions, a number of pairs of gages are necessary, placed at various intervals around the circumference of the pipe.

Fig. 1 shows a typical gage arrangement from which both longitudinal and bending stresses can be determined. This particular arrangement has a pair of gages every 45 deg around the pipe. Here again, the maximum stress will always be either in the circumferential or longitudinal direction and the use of pairs of gages is adequate to define the maximum stresses.

When it is desired to determine the **torsional or shear stresses** in a pipe, a pair of gages is not sufficient. Three gages with their axes in different directions are necessary. Such an arrangement is available commercially with three separate gage elements all built into one gage, known as a rosette gage. With this type it is possible to determine the maximum and minimum principal stresses and their directions and the shear stress at the gage position.

The **stress distributions in a fitting or branch connection** are somewhat more complicated than in straight pipe, therefore, more care must be used in selecting the gage positions to insure that they determine the maximum stresses. Some assistance in doing this can be obtained from a forthcoming AGA report on research conducted at Battelle on stresses in branch connections under internal pressure and external loads on the branch. When a branch connection installation is being investigated in the field, it would be advisable to place gages around the branch pipe at least two or three diameters away from the header in order to determine the axial and bending forces in the branch pipe.

Details on the selection of the proper types of strain gage and on the application of the gages in the field are given in Part II of this report. The most important part of applying gages for field use to insure their reliability over a long period of time is to obtain adequate protection of the gage against moisture and mechanical damage. This is also discussed in Part II of this report in some detail.

In addition to recording the strain-gage readings, it is advisable, in any set of field measurements, to record other data that may later be important in analyzing the results. Of course, the other desired data will vary from one problem to another; however, some examples are as follows:

1. Internal pressure,
2. Pipe temperature,
3. Weather conditions, including a record of rainfall (these are sometimes valuable in ascertaining whether a questionable gage has been sensitive to soil moisture),
4. Deflections or movement of the pipe in any direction that can be measured,
5. Electrical resistance from the gage circuit to ground (this is discussed in Part II).

Part II.

Use of Bonded-Wire Strain Gages On Pipe Line Systems

This part of the report covers some of the techniques used in the application of bonded-wire strain gages on pipe line systems. Although much of the discussion can be applied to the use of strain gages in general, the specific purpose of this part is to outline procedures for the determination of service stresses and secondary stresses in such applications as buried pipe lines, above-ground outdoor piping, and compressor-station piping.

Perhaps because of the basic simplicity of the strain gage itself, many misconceptions exist as to the amount of effort and knowledge required for successful strain-gage stress

analysis. In order to properly utilize this important tool, it is necessary to understand some of the theoretical aspects of strain-gage analysis as well as the practical aspects of applying and protecting the gages under adverse conditions.

Particularly in difficult field applications, as on piping systems under construction, the stress analyst must have a broad knowledge of what can be done with strain gages and, in addition, he must use good judgment in adapting these techniques to his own particular application.

For the convenience of the reader, this part of the report is divided into the following sections:

1. Selection of the proper type of strain gage,
2. Techniques for bonding strain gages,
3. Strain-gage circuits and instrumentation,
4. Methods of protecting strain gages from moisture and mechanical damage,
5. Special precautions for long-time strain-gage applications,
6. Analysis of results.

Selection of the Proper Types of Gages

All commercially available bonded-wire resistance strain gages are manufactured in this country by the Baldwin-Lima-Hamilton Corporation, which holds the patent rights on the gages and their application. The gages have been named SR-4 strain gages in recognition of the two men, Simmons and Ruge, who developed the principles of measuring surface strains by this method.

In their present state of development, SR-4 gages consist simply of a short length of very fine wire (about one mil in diameter), which is bonded to a paper base or molded in a phenolic resin base. In each case, the base serves as a convenient means to attach the wire grid to the test piece while, at the same time, providing electrical insulation between the grid and the test surface.

The operation of the gage is based on the principle that the insulated wire grid will be strained nearly equally with the surface of test piece. As the wire is strained its electrical resistance changes slightly. Accurate detection of this change in resistance provides a measure of the amount of strain in the wire and, therefore, the amount of strain on the surface of the test piece.

Grid Constructions

Fig. 2 illustrates several common types of SR-4 strain-gage constructions. The typical general-purpose gage (Fig. 2a) is constructed with the wire grid in the form of long parallel loops with all of the wires lying in the same plane. Actual grid lengths for this type of gage range from ⅜ to 6 in.

A second type of grid construction (Fig. 2b) is used generally in gages of ⅜-in. or less in length. In this case, the strain-sensitive grid wire is wound around a flat core in the form of a close-wound helix. The grid is then cemented between two protective paper covers or molded in phenolic resin.

A third type of construction (Fig. 2c and 2d) employs two or more grids, each laid over the other and oriented at specific angles. This type of gage is useful in determining the strains in biaxial stress fields or at locations where the direction of principal strain is not known.

As shown in Fig. 2, all of the gage constructions have larger diameter leads which are soldered or welded to the ends of the fine wire grid. This junction is the weakest point in the gage and a frequent location of gage failure. As will be discussed later, care must be taken not to disrupt the junction by rough handling, excessive bonding pressure, or overheating of the gage leads during installation.

Strain-gage grids are constructed from either constantan or Iso-elastic wire with the exception of several gages for specialized applications. The constantan gages, designated as Type "A," will be found to be the most suitable for almost all pipe line applications. The constantan gages are affected less by changes in temperature than the Iso-elastic gages and, consequently, they are preferred for static-strain measurements.

The Iso-elastic gages, on the other hand, have a greater strain sensitivity, which is an advantage in measuring dynamic strains of small magnitude. In the remainder of this report, the discusson is limited to gages constructed of constantan wire.

Paper and Bakelite Gages

In addition to the various types of grid configuration and wires, SR-4 strain gages may be divided into two major groups: (1) Paper-base gages and (2) Bakelite gages. In the first type, the grid is supported on a thin paper base impregnated with nitrocellulose cement. Gages of this type are sometimes referred to as "Duco" gages, because they may be bonded quite successfully with ordinary Duco household cement. The manufacturer also supplies a nitrocellulose cement (SR-4 cement) for this type of gage.

In the second type of gage, the grid wire is molded in a thermosetting Bakelite phenol resin. Bakelite gages require special cements and they are considerably more difficult to bond than paper-base gages; however, they offer several advantages from the standpoint of maximum operating temperature and stability.

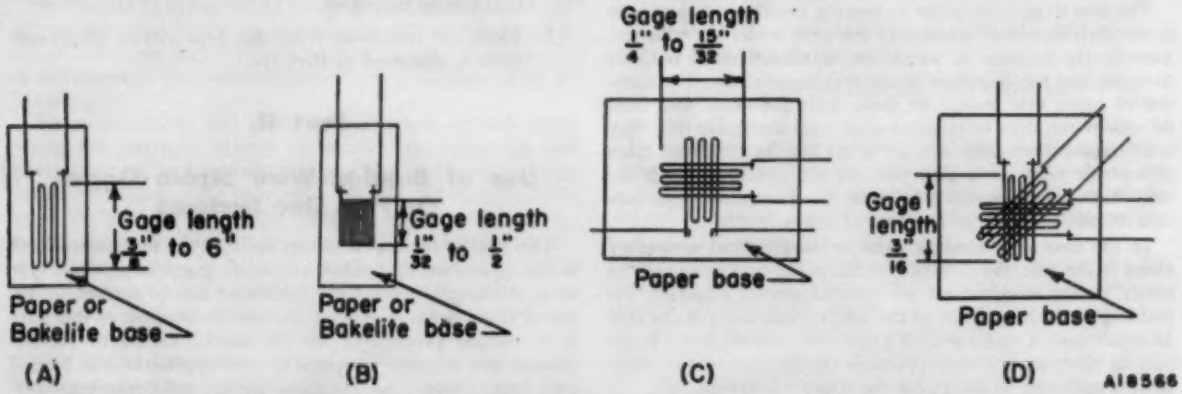

FIG. 2. Grid configuration for common types of SR-4 strain gages (a) General purpose gage with flat grid (b) Wrap-around grid construction used for short-length gages (c) Biaxial-rosette gage with flat or wrap-around grids (d) 45-deg rosette gage with flat grids.

Other Construction Variations

In summary, strain gages have the following major variations in construction:

1. *Type of base carrier material,*
2. *Grid construction,*
3. *Number and orientation of grids,*
4. *Grid and gage dimensions,*
5. *Type of grid wire.*

In addition, several types of gages are available for various specialized applications. These include gages with dual-lead construction, gages with special types of grid wire, and gages in which special cements are used to mount grid wire on the carrier base. Detailed information on these gages and their specific uses is given in Reference 8.

Factors in Proper Gage Selection

One of the first considerations in selecting the proper gage for a given job is the size of the grid. Available grid lengths for representative gages are shown in Fig. 2 and Table 1. In general, the length of the grid employed will be determined to some extent by the size of the test piece and the degree of stress gradient in the area under examination. In locations such as in fillets, welds, valve flanges, etc., the grid length might be limited by the physical dimensions of the test piece. Also, locations near severe stress gradients, such as areas close to welds, reinforcements, or other discontinuities in the piping system, would require the use of a fairly short gage length.

The second consideration in selecting the proper gage is the maximum operating temperature of the test piece. In general, paper-base gages may be used satisfactorily at temperatures up to 160F to 170F. However, where long-time measurements are made at temperatures near this maximum (160F to 170F), or in applications where the temperatures exceed this maximum (up to 450F), the use of Bakelite strain gages is preferable. Bakelite gages are preferred also under conditions of high humidity or other adverse conditions. (This is discussed further in the section "Special Precautions for Long-Time Strain-Gage Applications.")

Another consideration in proper gage selection is the type of stress field at the area under examination. In the case of uniaxial stress, i.e., where the member is in simple tension or compression, a single-grid gage oriented in the direction of maximum stress would be sufficient. In the more complex case of biaxial stresses, i.e., where the member is subjected to primary stresses in two directions, a double-grid gage (or two strain gages at 90 deg to each other) must be used.

When two gages or one double-grid gage is used, care must be taken to orient the gage grids in the direction of the principal stress. At points where the directions of principal stresses are unknown, a strain-rosette gage (or three strain gages at 45 deg or 60 deg to each other) must be used. The magnitudes, as well as the direction, of the principal strains can be calculated from the strain rosette readings so that no particular orientation of the gage with respect to the principal strain is required.

Techniques for Bonding Strain Gages

The operation of a strain gage is based on the principle that the strain-sensitive grid wire in the gage will be strained equally with the surface of the test piece. obviously, the surface strains can be transmitted to the wire by only one means — that is, through the bonding cement which surrounds the wire and adheres to the test surface. Sound bonding is, therefore, of paramount importance for the accurate measurement of surface strains.

This section covers some of the techniques of bonding strain gages which have been used on actual pipe line applications. For more detailed information on bonding in general, see References 7, 8, and 9. Fig. 3 shows photographically the

TABLE 1. Summary of Gage Characteristics and Bonding Details for Various Types of Strain Gages and Cements.

Gage Construction	SR-4 Gage Type	Grid Length inches	Gage Resistance ohms	Type of Cement	Air Drying Time* hours	Drying Time Under Heat: Hours	Drying Time Under Heat: Temp, F	Clamping Force	Maximum Operating Temperature, F
Flat grid, ordinary paper	A-1	1/16	120	Duco	20-24	10-12	120-160	1 lb	170
	A-5	1/8	120	SR-4	10-12	5-6	120-160	1 lb	170
	A-9	0	300	Armstrong, A-1	—	1	160	0 to 1 lb	170
	A-12	1	120	Epon 828,	—	1½-2	150	0 to 1 lb	170
	A-21	5/8	60	Activator D					
Flat grid, fast-drying paper	A-3	3/16	120	Duco	12	4	120-160	0 to 1 lb	170
	A-5-1	1/8	120	SR-4	5-6	3	120-160	0 to 1 lb	170
	A-6	1	300	Armstrong, A-1	—	1	160	0 to 1 lb	170
	A-12-1	1	120	Epon 828,	—	1½-2	150	0 to 1 lb	170
				Activator D					
Wrap-around grid, paper gages	A-7	1/4	120						
	A-7-4	1/4	60	Duco	48	12	120-160	1 lb	170
	A-8	1/8	120	SR-4	20-24	6-8	120-160	1 lb	170
	A-13	1/8	350	Armstrong, A-1	—	1	160	0 to 1 lb	170
	A-13-1	1/8	240	Epon 828,	—	1½-2	150	0 to 1 lb	170
	A-14	1/8	500	Activator D					
	A-19	1/8	60						
Bakelite gages	AB-1	1/4	350						
	AB-3	1/16	120						
	AB-5	1/8	75						
	AB-7	1/4	120	Bakelite	—	2-6	(see text)	100-200 psi	450
	AB-7-1	1/4	240	Armstrong, A-1	—	1	160	0 to 1 lb	200
	AB-11	1/4	120	Epon 828,	—	1½-2	150	0 to 1 lb	200
	AB-13	1/8	350	Activator D					
	AB-14	1/8	500	deKhotinsky	0	0	—	0 to 1 lb	125
	AB-19	1/8	60						
	AB-19-1	1/8	60						
	AB-32	1/32	120						

*Air-drying time is given for "average" conditions, i.e., room temperature of about 70 F or above with fairly low relative humidity. Under conditions of high humidity or low temperature, heat drying is essential (see text).

Type of Cement	Manufacturer or Supplier	Type of Cement	Manufacturer or Supplier
Duco	Any variety store	Armstrong, A-1	Armstrong Products Company Warsaw, Indiana
SR-4	Baldwin-Lima-Hamilton Corporation Philadelphia 42, Pensylvania	Epon 828	Shell Chemical Corporation 380 Madison Avenue New York 17, New York
Bakelite	Baldwin-Lima-Hamilton Corporation Philadelphia 42, Pennsylvania	deKhotinsky	Central Scientific Company Chicago, Illinois

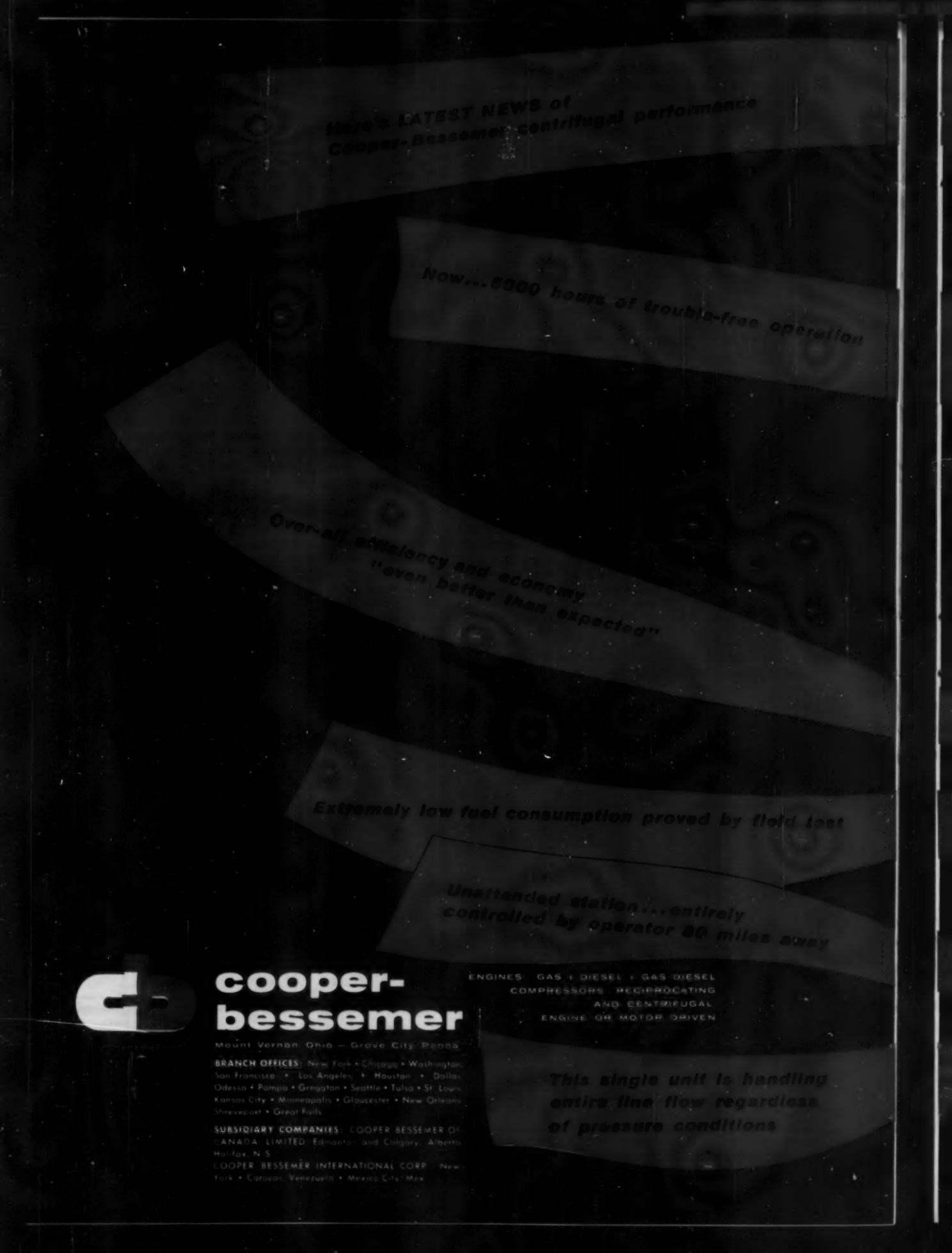
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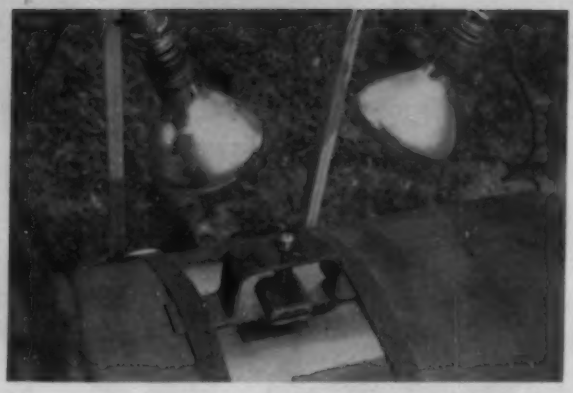
FIG. 3 **Steps in installation of strain gages**

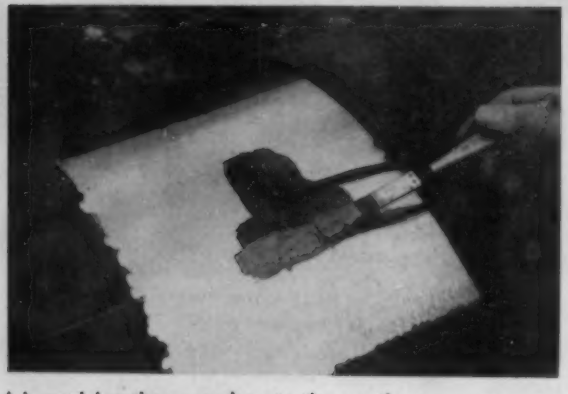
(a) sanding the surface



(b) clamping and heat drying the gages

(c) completely dried gages with leads attached

(d) applying the first protective coating



(e) applying the second protective coating.

(f) completely weatherproofed gages ready for test

various steps in preparing the test surface and in cementing, drying, and coating strain gages.

Preparing the Surface

The first step in bonding either paper-base or Bakelite gages is the proper preparation of the test surface. All rust, scale, paint, and oxide must be removed from the surface in an area a little larger than the gage. Where protective coatings will be applied over the gage later, it is advisable to clean the surface in an area several inches on each side of the gage. Surface pits, rough spots, or ridges must be removed by sanding if necessary, although care should be taken not to cause an undesirable reduction in thickness at the test area. If the surface is very smooth or highly polished, a better bond can be obtained by roughening it slightly with medium-grit emery cloth, using a circular sanding motion.

After the right degree of roughness is achieved, the surface must be cleaned chemically. A cloth saturated with a volatile solvent such as acetone, should be wiped repeatedly over the area.* For a final cleaning, it is preferable to wipe the surface with a saturated white cloth and to judge the area as "clean" when no discoloration appears on the cloth. After the

*Many of the solvents and their vapors are toxic on prolonged or repeated contact with the skin. Also, some solvents are highly flammable. Care should be taken to provide adequate ventilation during their use.

surface has been cleaned, it should not be touched again before bonding the gage since any oil or dirt will weaken the bond.

Actual bonding techniques will vary somewhat, depending upon the type of gage and cement used, the atmospheric conditions surrounding the gages, and the degree of stability required of the gage.

Applying Paper-Base Gages

Paper-base strain gages fall into three categories as far as bonding techniques are concerned. These are (1) flat-grid gages with ordinary paper base, (2) flat-grid gages with fast-drying thin-paper base, and (3) gages with wrap-around grids. Of these three types, the fast-drying flat-grid gages (such as Types A-3, A-5-1, and A-12-1) will probably be found to have the most use in pipe line applications.

Just prior to bonding, it is good practice to wipe the back of the gage with a clean cloth slightly moistened with acetone. Next, a liberal amount of cement is applied to the back of the gage and to the prepared test surface. The gage is applied to the surface immediately and rolled or pressed lightly with the fingers to remove the excess cement. At this stage, it is possible to slide the gage slightly to obtain the correct orientation.

The next step is to apply a weight or clamping force of about 1 lb to the gage. Fast-drying paper gages with flat grids do not require clamping. These are merely held under pressure with the fingers for one or two minutes. After the cement has had time to soften up the paper, the gage will stay in place even on curved surfaces or overhead locations.

When clamping is required, it is convenient to cover the gage with a cellophane tape to prevent the cement from sticking to the clamp. If conditions permit, a 1-lb weight placed on the gage makes a very suitable clamp. When a C-clamp or a wrap-around belt is used, as shown in Fig. 3b, it is desirable to place resilient material such as sponge rubber or a compression spring over the gage to keep the clamping force relatively constant as the cement flows or shrinks. Too large a clamping force will result in grounding or in a discontinuity in the grid wire.

After a half hour or longer, the weight or clamp and cellophane may be removed carefully and the gage allowed to air dry. Drying time will depend upon the conditions of humidity and temperature, the type of gage construction, and the type of cement used in bonding. Table 1 contains a summary of the drying times and bonding techniques for each type of gage. In general, the drying process can be greatly accelerated by the application of moderate heat. For example, using Duco cement with a fast-drying paper gage, the drying time at normal room temperature would be 12 hours. This may be reduced to about four hours by proper heating.

Under conditions of high humidity or low temperature, it is absolutely necessary to heat dry the gages in order to drive the solvent out of the cement. Ordinarily infrared heat lamps work very well for this purpose (see Fig. 3b). After at least one hour of air drying, the temperature of the gage and surrounding metal should be brought up very slowly to 120 to 170F for the prescribed period of time. If the temperature is brought up too rapidly, bubbles tend to form in the cement, destroying the effectiveness of the bond.

It should be pointed out that in some pipe line applications the problem will not be in heating the test surface but rather in cooling it for the initial installation of the gages. In direct sunlight on a hot day, the temperature of a pipe in the field might easily reach 120F or above. In this case it would be best to pan the work so that the gages are installed on the pipe during the cooler hours of the day.

In some other field installations, it may be found necessary to apply gages to a line that is in service and has flowing gas inside. This can lead to difficulties from moisture condensation on the outside of the pipe wall if the temperature of the flowing gas is lower than the dewpoint of the surrounding air. In occasion, it has been necessary to delay the application of the gages until the dewpoint of the atmosphere was low enough that no condensation took place.

Where field conditions require a very fast drying time, the use of an epoxy resin cement (such as Armstrong A-1) might be advantageous. This is two-part adhesive which requires mixing just prior to use. The cement can be cured in about two hour at 160F with little or no clamping pressure required. The maximum operating temperature for this cement is 200F (see Table 1).

Applying Bakelite Gages

Bakelite strain gages are used, generally, where the operating temperatures fall within the range of 150 to 450F, or where long-time gage stability is required under adverse conditions. The method of preparing the surface and installing the gages is similar to that used for paper gages. The major differences in technique are found in the clamping pressures and curing cycle required for Bakelite gages.

The following procedures are used to bond gages with Bakelite cement of the type furnished by the manufacturer:

1. Clean the underside of the gage with solvent,
2. Apply cement to gage and test surface, eliminating and air bubbles,
3. Apply gage to surface and cover with a strip of cellophane tape,
4. Place a metal-backed felt or neoprene pad over the gage and apply clamping pressure (25 psi minimum — 100 to 200 psi desirable),
5. With the gage under clamping pressures, the temperature should be raised slowly to 140F for 1 hour, 175F for 2 hours, and 250F for 2 hours; the gage stability will be improved considerably by an additional hour of baking at 275F after the clamp has been removed,
6. If the gage is to be used above the highest curing temperature, it should be cycled to the maximum expected temperature several times before the test begins.

Obviously, the above conditions are difficult to achieve in field applications. For this reason, Bakelite gages are frequently bonded with an epoxy resin cement (such as Armstrong A-1 or Epon 828). This greatly reduces or eliminates the clamping requirements and reduces the baking cycle to about 1 to 2 hours at 160F. The use of epoxy cement, however, reduces the permissible operating temperature to 200F.

Where an extremely short drying time is required, the use of deKhotinsky cement might be considered. This adhesive comes in stick form and is applied directly on the prepared surface after heating the surface to about 285F. The gage is then put in place and held under light pressure for a few minutes until the cement cools and hardens. This adhesive is used only with Bakelite gages because of the high initial temperature required.

At first, it may appear that the drying time required for strain gages would be a serious drawback to their application under some field conditions. In most cases, however, the time required for drying the gages will not be longer than that required to complete the wiring and other preparations for testing. To obtain accurate readings and avoid the possibility of "gage creep" during the test, it is of the utmost importance to allow full drying time at the prescribed temperatures.

Experience has shown that, in applying gages in the field, where they may be limited time, and where it is not possible to heat the pipe or other component, one of the flat-grid, fast-drying gages, such as the A-3 applied with Duco cement is the best one to use.

* * *

The remainder of this article will appear in the December issue of *The Pipeline Engineer*.

PIPE LINE COMMUNICATION & CONTROL

Microwave System Planning

A graphical approach to simplified point-to-point system planning

Part 6: Microwave RF Links

Lee Elmore
Collins Radio Company

ABOUT PART 6 OF THE SERIES

A microwave system is basically one or more point-to-point RF links capable of transmitting communication and control information. Each link consists of transmitting and receiving equipment and a highly directional antenna system at each end of a line-of-sight path. In a multi-hop microwave system involving many links in series, each link must be carefully planned for the desired reliability. The RF link is gaged in terms of received C/N ratio, which is the db sum of transmitter power, antenna system gain, space loss, and receiver threshold.

Pipe line microwave systems operate in the 960 mc, 2000 mc, 2600 mc and 6700 mc frequency allocation bands. Equipment techniques, antenna arrangement, db factors, information capacity, and cost vary somewhat with bands.

This article summarizes microwave techniques and frequency considerations for all four bands. A full-page Microwave RF Link Planning Graph is presented to aid in graphically "calculating" link performance for all path lengths, frequency bands, dish sizes, and transmitter-receiver gains. An inset corrects for reflector gain at 6700 mc and coax loss at 2000 mc for various tower heights.

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Microwave Allocations And Usage

The petroleum radio services, along with other industry, utility and public safety services, have been allocated radio spectrum for microwave communication in the operational fixed bands shown in Table 1.

The 960-mc band is employed by pipe lines for a small number of single-hop systems carrying one or a few channels, primarily because most of the equipment packaged for this band is suitable only for such limited usage. The 960-mc band can be used for medium density traffic in multi-hop systems, provided that equipment design and quality are based on communication standards rather than commercial motives.

TABLE 1. Operational fixed microwave bands.

Nominal band	Frequency allocation range	Available Spectrum width
960 mc	952 — 960 mc	8 mc
2,000 mc	1,850 — 1,990 mc	140 mc
	2,110 — 2,200 mc	90 mc
2,600 mc	2,450 — 2,500 mc	*50 mc
	2,500 — 2,700 mc	200 mc
6,700 mc	6,575 — 6,875 mc	300 mc
12,000 mc	12,200 — 12,700 mc	500 mc

Both the 2000-mc and 6700-mc band are being widely used for multi-hop, multi-channel communication systems. The 2600-mc band is considered part of the 2000-mc band. Location, ownership, number of stations, frequency band and channel usage are tabulated in the August, 1956, issue of PE for the 17,000 miles of pipe line microwave systems.

Microwave users outside the petroleum industry are seen to strongly favor the higher bands. AT&T's transcontinental TD-2 radio relay, which provides the backbone of our national communications, operates in the 4000-mc common carrier band. The TE system, employed for spur TV routes, also operates at 4000 mc. Newer versions of these equipments are reported forthcoming for use in the 6000-mc common carrier band. Most microwave purchases by Bell and the independent telephone companies have been in the 6000-mc band. The vast bulk of microwave equipment procured by the U. S. Armed Forces for overseas military communication has been in the 7500-mc government band.

TABLE 2. Microwave techniques.
(Employed in current pipeline communication systems)

Item	Characteristics	6700 MC	2000 MC and 2600 MC	960 MC
Transmitter	Tube type	Reflex klystron	Lighthouse triode	Lighthouse triode
	Power output	150 mw. 1 watt	1.5 to 3 w. avg.	3 to 5 watts
	Average life	4 yr. 1 yr.	7 — 9 mo.	7 — 9 mo.
	Aging factor	—0—	—3db	-3db
	Frequency generation	Direct (klystron)	Crystal osc. and Multiplication	
	RF modulation	FM (klystron repeller)	Pulse or FM (phase modulation)	
Antenna system	Dishes per link	2 (duplexed trans. and rec.)		4
	Transmission line	Waveguide	Pressurized coax (⅞ in or 1⅝ in.)	
	Tower-mounted	Reflector	Dish and coax line	2 antennas and lines
	Duplexer losses	1 db per end	1 db per end	Not duplexed
	Ferrite isolator	1 db forward loss	unidirectional line not available	
Receiver	RF bandwidth	10 to 15 mc	5.6 to 8 mc	0.2 to 2 mc
	Noise figure	12 db	12 db	11 db
	Rec noise (KTB+N.F.)	—90 dbm	—91 dbm	—99 to —113 dbm
Gain (link)	Transmitter-receiver	108 to 118 db	120 to 126 db	122 to 130 (practical)
	Passive (pair 6-ft dishes)	79 db	58 db to 63 db	46 db
	Passive active gain	70%	50%	37%

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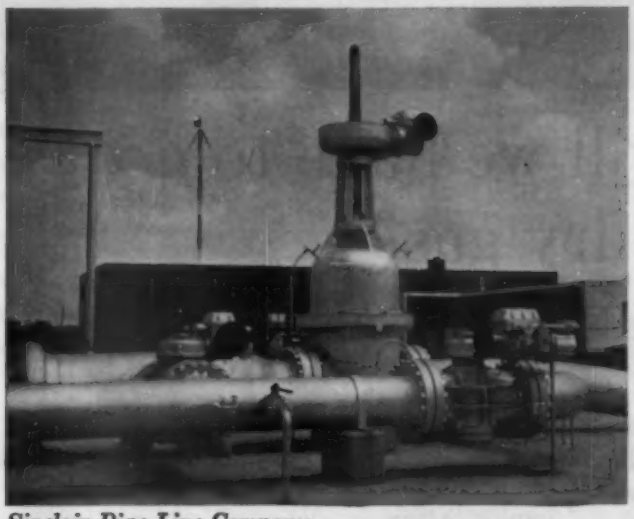

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The bands above 10,000 mc have been employed for radar and experimental purposes, but have not yet been used for commercial communications.

Choice of Band

Selection of microwave equipment for a pipe line communication or control system is not simply a matter of megacycles, db's, and dollars. Db-wise, stations can be linked readily at any frequency band. All too often, the choice is simply low-dollar or fastest pay-out. There is very little correlation between frequency and how cheaply a system can be bid; we get what we pay for in *quality*, not *megacycles*.

The relation between frequency and cost is mixed. For example, 6700-mc equipment is more economical, but the use of 50 per cent standby at 2000-mc relay stations often reverses this economic position.

From an engineering and management standpoint, the choice should be on the basis of:

1. **Long-range economics (amortized cost plus maintenance over 10-year operation using discounted cash flow method).**
2. **Anticipated expansion of communication traffic and control functions (10-year prediction to avoid early obsolescence due to limited microwave capacity).**
3. **The desired circuit quality and continuity of operation (considering possibility of centralized accounting and automatic pump station control).**

The engineer should plan his system with the above points in mind. He must estimate accurately and justify his project cost allocation. He should keep his management posted on technological innovations as it may affect planning for operational economics or growth potential. The communication engineer has a major responsibility in preparing his specifications to assure receipt of well-engineered bids from all desired suppliers. He may specify important parameters such as frequency band, fade margin, dish size, standby provisions, RF and power switching time, voice circuit quality or type of multiplex. If he prefers to leave the bidders full freedom, he should thoroughly evaluate and normalize the bids to assure delivery to full intent of his specification.

TABLE 3. Nominal path loss.

F Frequency band	α Free-space loss (30mi)	G Dish gain (6' dia.)	α-2G Nominal Path loss
6,700 mc	143 db	39.5 db	65 db
2,000 mc	135 db	31.5 db	72 db
2,000 mc	132.5 db	29 db	74.5 db
960 mc	126.2 db	23 db	80.2 db

Typical 6700-mc tower and antenna system, showing dishes on building and passive reflectors mounted at tower top.

From an operating and maintenance standpoint, the choice should be on the basis of:

4. **Reliability, simplicity, and ease of maintenance of radio equipment, antenna system, and power provision.**
5. **Provision of full standby radio equipment and emergency power to avoid outages during tube or power line failure.**
6. **Provision of multi-function fault alarm system to monitor system performance and provide fault indications.**
7. **Simple and straight-forward preventive maintenance, troubleshooting, and fault correction (considering built-in and portable test apparatus, available spare plug-in units or parts, detailed manuals, and field service back-up from suppliers).**

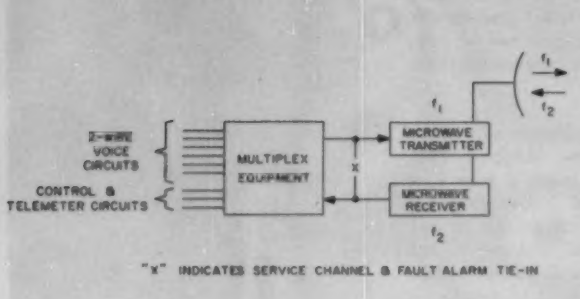

FIG. 1. Microwave terminal.

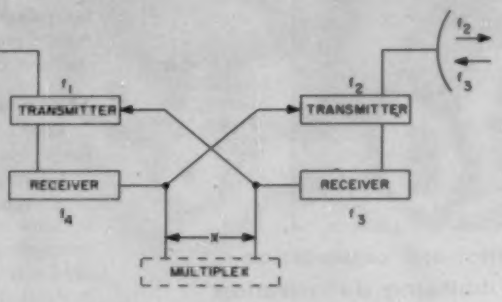

FIG. 2. Back-to-back repeater.

When the microwave system has been planned and contracted on the basis of the above seven points, the proper choice of frequency band will be axiomatic.

Microwave Techniques

Any of the bands between 960 mc and 6700 mc may be employed to provide point-to-point microwave links. Insofar as propagation reliability is concerned, these bands are essentially the same, as will be shown later in this series when we consider propagation fades as related to system performance.

The major difference between frequency bands lies in the *equipment* and *techniques* employed in the transmitter and antenna system. In the lower bands (960 mc, 2000 mc, and 2600 mc) the transmitter tubes, RF generating method, power levels, antenna system, dish gain, and maintenance program differ considerably from the high band (6700 mc). These techniques are summarized in Table 2 to permit ready comparison of 960, 2000, 2600, and 6700 mc.

The tower requirements and heights differ somewhat with frequency band. The wider Fresnel Zone at the lower bands necessitates taller towers to provide proper clearance for 960 or 2000-mc systems to assure propagation reliability under inverse bending conditions. The narrower beam width of parabolic dishes operating in the high band necessitates sturdier towers for 6700-mc systems.

The information-carrying capacity of a microwave system also is partially dependent upon frequency band. Wide-band RF circuits are more readily obtained at higher frequencies. A wide RF bandwidth may be employed to transmit more information or to buy improvement in the intelligence S/N ratio. Receiver bandwidth is typically 14 mc at 6700 mc, 7 mc at 2000 mc and less than 2 mc at 960 mc. At 6700 mc, an information-carrying video bandwidth of over one megacycle may be employed in high-density communication systems (240 channels), and this bandwidth is extended to 7 megacycles when required for transmission of color television and high-fidelity audio channels. The relation between bandwidth, number of channels, and signal-to-noise improvement for various multiplex systems will be covered in a forthcoming article on channelizing.

Radio Relays

A microwave terminal at one end of a single link or multi-hop system is shown in Fig. 1.

A number of voice, teletype, telemetering, control, facsimile, or data transmission circuits may be impressed on a single microwave RF carrier by multiplexing equipment (to be covered later in the series). The multiplexed intelligence is transmitted toward the adjacent station, and incoming multiplexed intelligence is recovered from the local receiver.

In a single link or one-hop system, the adjacent station will be identical except for a reversal of F_1 and F_2. In a multi-hop system, however, we must repeat the RF signal at a number of intermediate relay stations. Thru relay stations exist simply to retransmit the microwave signal, thereby maintaining a line-of-sight path and compensating for space losses. At drop relay stations where communication circuits are required, the multiplexed intelligence must be available for access by bridging or drop-and-insert techniques.

A 1500-mile pipe line microwave system may require 50 to 60 relay stations in series, with various channel drops along the route. The repeater performance and ease of drop-and-insert becomes an important consideration in system planning.

Multiplexed intelligence inserted at one end and along such a system must emerge at the far end as highly intelligible English and accurately reproduced control impulses or telemetering data. The repeater characteristics, cumulative noise build-up, linearity of transfer characteristic, modulation level control, frequency control scheme and type of multiplex loading must be carefully considered in planning long systems. After covering channelizing equipment and loading, we will devote an article in this series to multi-hop system planning.

Three types of microwave repeaters are in use today: (1) Back-to-back, (2) heterodyne, and (3) feedback. Each has its relative merits and shortcomings, but all perform the function for which they were designed, as evidenced in the existing systems that utilize these repeater types.

The back-to-back repeater, shown in Fig. 2, is functionally a pair of cross-connected terminals. The output of each receiver is fed to the opposite transmitter, so that the signal is simply received and re-transmitted in each direction. As the interconnection is at video, the entire baseband is readily available for channel drops. The service channel and fault alarm are also simply bridged across the inter-connection.

The hetrodyne repeater, shown in Fig. 3, converts the received microwave signal to a convenient IF for amplification, then reconverts back to a new microwave RF frequency for outgoing transmission. Three mixers, two oscillators and two different IF amplifiers are required for each repeater direction. The outgoing RF signal is shifted in frequency by the IF difference.

The through signal is heterodyned to IF but not demodulated to video. Those channels that are dropped and inserted are demodulated to video and reinserted through an FM modulator.

As the frequency of each repeater is dependent upon the preceeding station, precise frequency control must be maintained at the terminal. To avoid operating beyond FCC frequency tolerances, each hetrodyne repeater must have local control that takes over in case of loss of incoming signal due to propagation fade or outage of a preceding station.

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MICROWAVE RF LINK PLANNING GRAPH

Carrier-to-noise ratio (C/N) vs. path length (L)

CHART USAGE:

DIRECTLY APPLICABLE TO ALL BANDS. FOR SPECIFIC EQUIPMENTS, COMPARE TR GAIN WITH TYPICAL VALUES (INSET "A") AND CORRECT C/N BY DIFFERENCE.

$$C/N = TR + 2G - \alpha \pm Z$$

TR = EQUIPMENT GAIN IN DB
= TRANSMITTER POWER - RECEIVER THRESHOLD
= 10 LOG P_{AV} - (KTB + N.F. + DUPLEXER LOSS)

G = DISH GAIN = 20 LOG f + 20 LOG d − 52.5

α = SPACE LOSS = 37 + 20 LOG f + 20 LOG L

Z = ANTENNA SYSTEM CORRECTION FACTORS (SEE INSET "B")

(F = FREQUENCY IN MC, D = DIAMETER IN ft., L = LENGTH IN MILES)

RF CARRIER TO NOISE RATIO (IN DB)

70 60 50 40 30

Ⓐ C/N PLOTTED FOR TYPICAL MAINTAINABLE EQUIPMENT GAINS:
- 110 db AT 6700 MC
- 117 db AT 2600 MC
- 120 db AT 2000 MC
- 125 db AT 960 MC

C/N with 8' PARABOLAS

C/N with 6' PARABOLAS

C/N with 4' PARABOLAS

Ⓑ CORRECT C/N BY TOTAL ± DB SHOWN FOR ANTENNA SYSTEM, FREQ. BAND & TOWER HEIGHT AT EACH END OF LINK.

6700 MC REFLECTOR

WITH 6' DISH | WITH 4' DISH

+3 +2 +1 0 −1 −2 −3

8'x12' 8'x12' 6'x8'

100' 200' 300'

REFL.-DISH SEPARATION

COAX TRANSMISSION LOSS

960 MC 2000 MC 2600 MC

(RIGID AIR DIELECTRIC, FITTING LOSSES 1 DB)

DB

7/8" DIA.

1 5/8" DIA.

0 −2 −4 −6 −8

100' 200' 300'

COAX LINE LENGTH

4 5 6 7 8 9 10 20 30 40 50 60 70 80 90 100

PATH DISTANCE IN MILES

In long systems involving hetrodyne repeaters, the series is usually broken by introducing a back-to-back repeater at reasonable intervals.

The feedback repeater shown in Fig. 4, employes a single microwave oscillator and transmitter. The oscillator is locked to the incoming signal and displaced by an amount equal to the IF.

The feedback loop that maintains this relation, however, requires a small error voltage (as does any servo loop) and imposes stringent requirements on the overall passband to avoid regenerative effects. The video baseband is limited in practice, and the degradation is somewhat greater than in the preceding types. Like the hetrodyne repeaters, all feedback repeaters ingeniously track in frequency. The chain is broken at intervals by a back-to-back repeater on full drop to audio.

The feedback repeater is an ingeniously simple device in principle, and is the closest approach to a true repeater yet marketed.

The ideal repeater would simply provide wideband RF amplification to re-transmit the signal at the original level. While we are dreaming we should include self-powering to eliminate dependence on a-c power lines or re-fueling of engine-generators. Simple and reliable drop facilities also should be provided. Relay stations could then be placed as required without major investment or upkeep.

With the stimulus of exponentially expanding communication networks, much idealized relay stations will be attained eventually. Traveling wave tubes are providing direct RF amplification on an experimental basis. Transistorized circuitry with almost infinite life expectancy and low power drain is being used in a few simple communication equipments. Solar batteries that generate 90 watts per sq ft from sunlight energy are being field tested in conjunction with storage batteries to provide continuous and reliable self-powering for simple pole-mounted telephone apparatus.

Although technological progress is exponential in rate, such realization is at least a decade away. Fortunately, available equipment will fulfill our communication requirements for the present with ready expansion to meet the needs of the next 10 to 20 years.

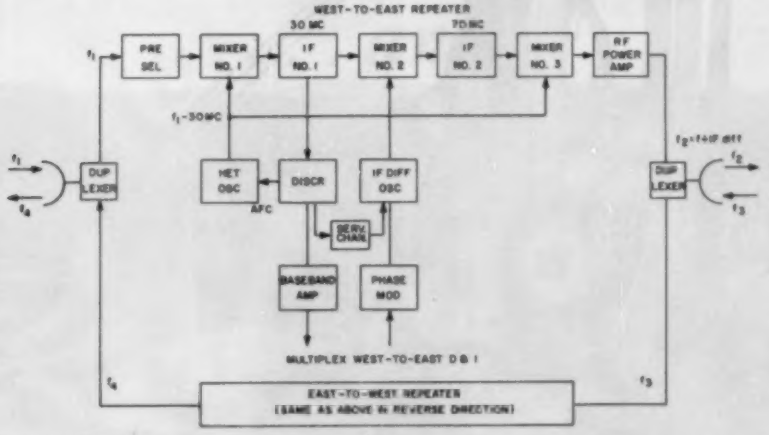

FIG. 3. Hetrodyne repeater.

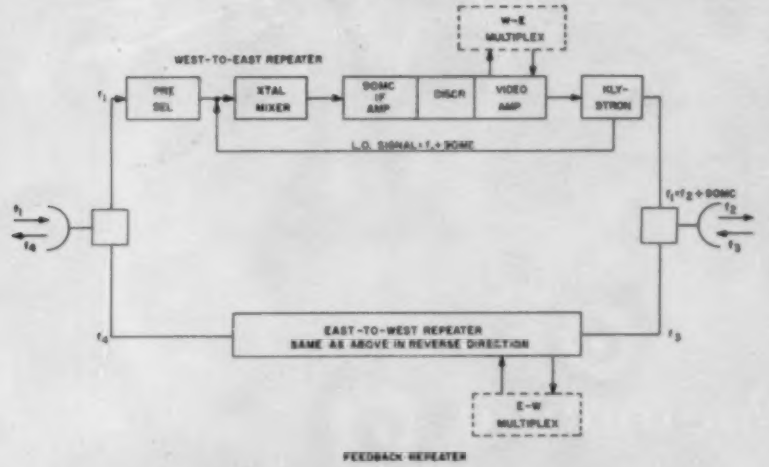

FIG. 4. Feedback repeater.

Transmitters

Microwave transmitters require special tube types to generate or amplify signals of extremely short wavelengths. Magnetrons are used to generate powerful RF pulses of short duration for radar, but are not readily tamed for communications. Klystrons and special disc-seal triodes ("Lighthouse tubes") are universally used for microwave oscillators and/or buffers.

Klystrons, originally developed as local oscillators for radar receivers, have provided the nucleus for microwave communication at 4000 mc and above, where high dish grains permit low transmitter power (0.1 to 1.0 watt). High-power klystrons are now available for microwave (50 watts at 7000 mc) and scatter (1 kw or 10 kw at 1000 mc).

The klystron has proved to be the answer to a communication engineer's prayer. In one bottle, the klystron does the following:

1. **It generates microwave energy directly at transmitter-power levels (without multiplier stages or buffers).**
2. **It is readily tunable both mechanically and electronically (for simple manual tuning and automatic frequency control as required).**
3. **It can be directly frequency-modulated by a low level voltage on the repeller (with a linear FM microwave output vs AM video input characteristic).**
4. **It lasts an average of up to four years (dependent upon tube type) and fails in predictable fashion (by slowly decreasing beam current).**

With such talents and long-life history, it is easy to see why seven new microwave communications transmittors have been designed around a klystron in the last six years.

Low-band transmitters employ a crystal oscillator, several multiplier stages, a buffer, and power amplifier. The last three stages in a 2000-mc transmitter are usually lighthouse triodes, and a lighthouse tube is sometimes used in the oscillator stage.

The lighthouse tube costs about one-third the cost of a 150-mw klystron,

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Tough Sections

. . . and comes back for more!

but the shorter life and multiple usage of lighthouse tubes cause the annual replacement cost to run three or four times that of the klystrons used for transmitters and local oscillators in a comparable relay station.

The power output of a conservatively operated lighthouse tube is 5 watts at 960 mc, 2.5 watts at 2000 mc, and 1.5 watts at 2600 mc. This inverse relation between allowable power and frequency tends to partially offset the decrease in antenna gain at lower frequencies.

Antenna System

Antenna and transmission line techniques are quite different in the high and low bands. At 2600 mc and below, the parabolic dish is mounted on top of the tower and connected to the transmitter by a coaxial transmission line. This line must be pressurized with dry air or gas to keep moisture from condensing and shorting the spacers. Rigid air dielectric coax is usually employed. At 2000 mc, ⅞-in. coax produces 2.2 db loss per 100 ft. On tall towers 1⅝-in. coax is used to reduce the loss to 1.2 db per 100 ft.

At 6700 mc, passive reflectors can be mounted at tower-top level and used to reflect the beam, mirror-fashion, toward the next station. The reflector is illuminated by the narrow beam emanating from a horizontal dish mounted on top of the equipment shelter or at the base of the tower. The dish heater, feed horn de-icer, and all other active elements are readily accessible for maintenance. The only tower climbing necessary is to change beacon lamps (where they are required by CAA), repaint every two years, and re-check reflector alignment annually.

Waveguide, rather than coax, is employed to connect dish and transmitter at the high bands. Rectangular waveguide employed for transmission lines and RF equipment "plumbing" at 6700 mc is ¾ by 1½-in. with the short dimension limiting power level and the long dimension fixing the low frequency cutoff (4300 mc) which eliminates all low-frequency interference.

As the dish need not be tower-mounted, waveguide runs are usually quite short. Long waveguide runs can be employed when necessary, provided the RF equipment incorporates ferrite load isolators. Long tower-mounted waveguide runs, like coax, are lossy (0.036 db per ft) and may require pressurization. Moisture condensation cannot short waveguide, but it will increase the VSWR.

Relatively small reflectors are required to intercept the narrow beam at 6700 mc. As the reflector may provide up to 3 db gain or 6 db per hop (with 8 by 12-ft reflectors, 4-ft dishes, and 150-towers), the use of tower-mounted reflectors is not only practical but advantageous.

Reflectors have recently been marketed for use at 2000 mc with loss no greater than coax-fed dishes for equal tower height.

At both 2000 mc and 6700 mc, duplexing techniques are employed to connect the transmitter and receiver to a common antenna system. This is not practical at 960 mc, however, and two separate dishes and transmission lines are tower-mounted at each end of a link.

Receivers

Microwave receivers essentially are long IF strips with auxiliary circuits. Superhetrodyne action is employed to convert the RF signal to a convenient IF where the desired amplification and selectivity are obtained. An RF filter is employed to pre-select the signal before conversion. Crystal mixers usually are employed for conversion, with local oscillator injection from a L. O. stage or obtained from the transmitter by special circuitry. Local oscillator AFC is provided to maintain the IF passband centered with respect to the received frequency. Limiting and AGC are provided for FM receivers so that the discriminator output voltage level is con-

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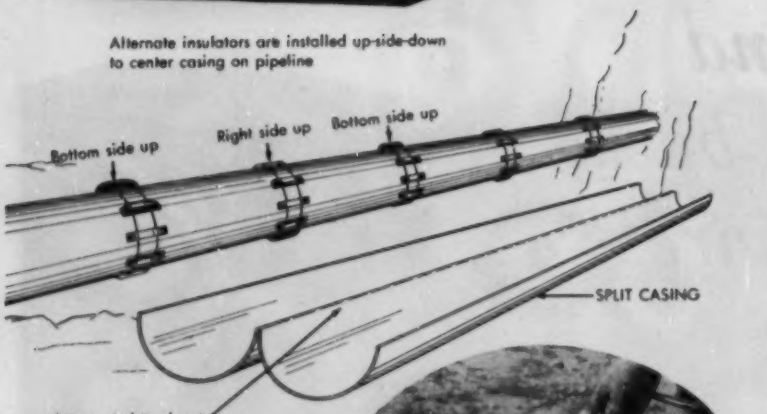
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stant despite varying RF carrier level due to propagation fades down to the threshold region.

As IF strips contain the bulk of tubes in an RF equipment and provide most of the "hot" db gain (as opposed to "cold" dish gain), they should be considered carefully from a maintenance standpoint. Elimination of interstage adjustments, use of plug-in IF strips, and low-voltage operation of reliable tube types will pay dividends in reduced failures and simplified maintenance.

In calculating the db performance over an RF link, the only receiver parameters of interest are bandwidth and noise figure. Receiver bandwidth is determined by the IF frequency response (so long as the adjacent transmitter frequency does not shift excessively and result in local AFC action causing the preselector to "chop" the IF response curve).

Bandwidth must be high in pulse systems to avoid causing round-shoulders on the pulse. Optimum bandwidth occurs in the vicinity of $B_\tau = 1.2$, where B is receiver bandwidth in mc and τ is pulse length in microseconds.

Bandwidth can be reduced in frequency division systems, or may be used for greater information capacity or S/N improvement as discussed earlier.

Receiver noise, which limits sensitivity, is defined in db terms as

$$N = KTB + NF$$

where KTB is thermal noise and NF is the measured noise figure.

Thermal noise, KTB, is the product of Boltzman's constant, absolute temperature in degrees Kelvin, and the receiver bandwidth. KTB is –114 dbm for a 1-megacycle bandwidth, and each octave of receiver bandwidth above 1 mc adds 3 db of noise power.

Noise figure is the measure of how much higher the receiver noise is than the theoretical noise power, KTB. In a typical microwave receiver with a noise figure of 12 db, the major noise source is the mixer crystal, which contributes approximately 8 db. The secondary noise source is tube noise (shot noise and induced grid noise) which can be reduced to 3.5 db by a well designed cascode input stage at the head of the IF strip.

In measuring receiver tangential sensitivity, the pre-selector cavity or duplexer loss is included with the noise figure.

Link Calculations

A carrier level diagram, such as Fig. 5, illustrates the relation of transmitter power, dish gain, and space loss to the received carrier level, C. Receiver noise level, N, as defined previously also is

how to
CUT CORROSION LOSSES
a report by Koppers Company, Inc.

W. F. Fair, Jr.
Corrosion Consultant

The two most recent reports in this monthly series have stressed the importance of good surface preparation and described methods used to clean metal surfaces prior to the application of protective coating systems. This report describes an experiment, conducted under service conditions, which illustrates striking differences in coating performance due solely to differences in surface preparation.

• • •

In 1952 speculation arose concerning the contribution of wash primer surface conditioners and of inhibitory pigmented primers, when used with coal tar coating systems. Dr. Joseph Bigos of the Steel Structures Painting Council, and editor of the Steel Structures Painting Manual, participated in the discussions, giving freely of his time and experience.

When it was decided to subject certain typical protective coating systems to an environment of known high corrosivity, two areas in the Koppers Coke Plant at Kearny, N. J., were selected. The location of this plant on tide water, fumes and "coke breeze" from adjacent ovens, saline condensation from the coke quenching, and seasonal temperature shocks assured rugged testing conditions.

The areas tested were an actifier tower and three oxide box tops, totaling nearly 5,000 sq. ft. of steel surface. Fourteen coating systems were applied in duplicate 2-foot-wide strips on the vertical actifier tower, after thorough sandblasting. Of the flat box top areas, half were cleaned by sandblasting and half by power wirebrushing, and the same fourteen coatings were applied on both of these differently cleaned areas.

Primers used were a conventional coal tar cutback, three wash primers, two epoxy red leads, two phenolics, four special proprietary formulations, and three experimental coal tar solutions. Barrier coats over primers were Bitumastic® No. 50, Bitumastic Super Service Black, and Bituplastic® No. 28. For comparison, unprimed sections received the same coatings. Bituplastic No. 28 was used to topcoat all areas.

• • •

At the end of only one year, all systems on the wire-brushed areas—both primed and unprimed—had blistered and soon showed universal disbonding. After two years, disbonding and undercutting on these areas had caused complete coating failure. Now, after more than three years, all the coating systems on the sandblasted areas—both primed and unprimed—are in perfect condition and show no signs of deterioration.

In such severe corrosion environments, it is obviously futile to consider any but the best surface preparation. Also, it must be concluded that priming cannot compensate for incomplete metal cleaning.

• • •

Our Technical Department makes semi-annual inspections of this continuing test. We'll be glad to notify you of these inspection tours if you would like to be present. Write Koppers Company, Inc., 1301 Koppers Building, Dept. 105L, Pittsburgh 19, Pa. District Offices: Boston, Chicago, Los Angeles, New York, Pittsburgh and Woodward, Ala. In Canada: Koppers Products, Ltd., Toronto, Ontario and Edmonton, Alberta.

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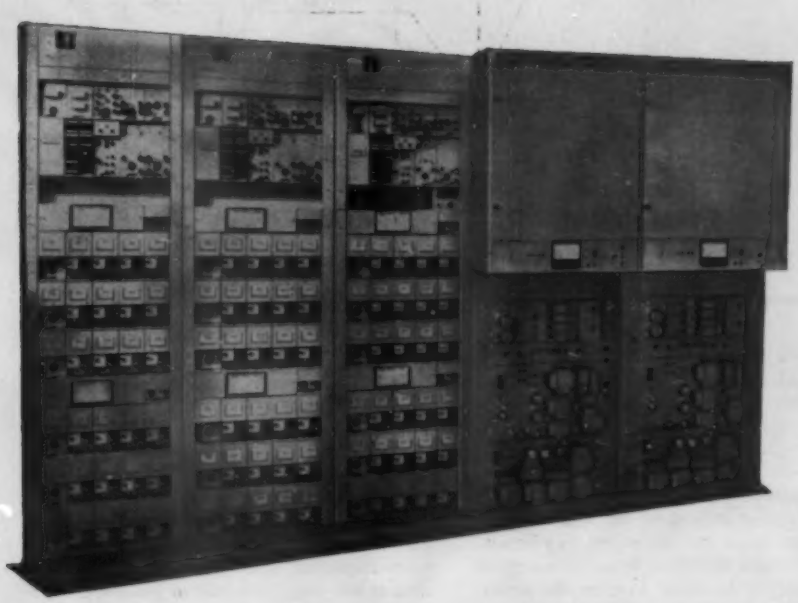
Microwave "Packages"



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- **Expandable to 60 channels**
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depicted. The difference between C and N levels or **C/N ratio** in db, is a **measure of usable RF carrier at the receiver output for a given set of transmission parameters.**

Transmitter-Receiver equipment gain, TR, is defined as the db difference between transmitter output power, P_{av}, and receiver noise level, N. TR is readily calculated for any transmitter average power, receiver RF bandwidth and receiver noise figure, with cavity and duplexer losses included in the latter. Some db allowance for aging (decrease in transmitter power or increase in receiver noise) should be incorporated to permit link calculations on the basis of readily maintainable equipment gain.

The C/N ratio is seen to be the db sum of equipment gain, antenna system gain, and space attenuation.

$$C/N = T\text{-}R + 2G - \alpha \pm Z$$

Where T-R is transmitter-receiver equipment gain

- G is parabolic dish gain
- α is free space loss
- Z is reflector-dish gain or transmission line loss.

As G is a function of frequency and dish size, and α is a function of frequency and path length we can plot C/N vs path length for various dish sizes at each band for specific equipment gains.

Equipment gains are typically 110 db in the 6700-mc band and in the order of 120 db at 2000 mc. (A 3 db aging factor should be incorporated in the low bands to allow for slump in output of lighthouse tubes.) The 960-mc equipment is limited below theoretical in practice to approximately 125 db.

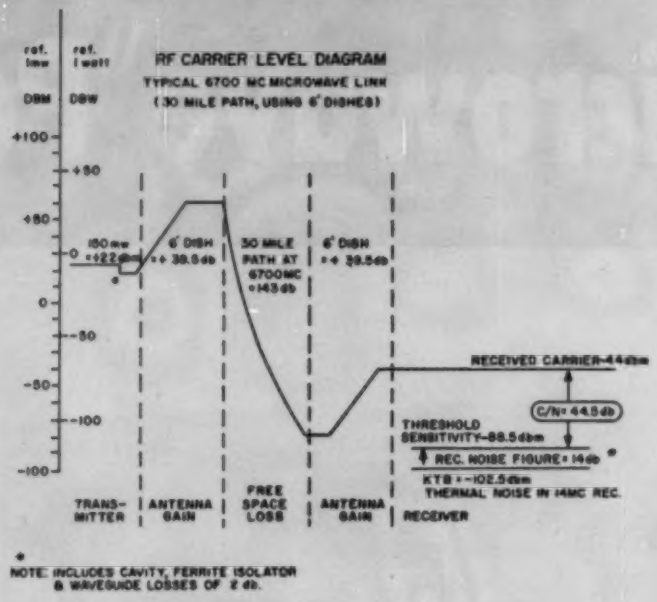

FIG. 5. RF carrier level diagram.

The net path loss, β (equal to α-2G), is seen in Table 3 to vary inversely with frequency. The nominal path loss at 2000 mc is seen to be 9.5 db higher than 6700 mc.

This increased path loss of 9.5 db is approximately equal to the increased equipment gain of 10 db. The same relation holds for the other two bands. **C/N ratio therefore is independent of frequency band, so long as the equipment gain agrees with our typical values.**

C/N is plotted in the full-page Microwave RF Link graph to cover all parameters in planning a microwave hop. The graph shows C/N vs distance for 4, 6, and 8 ft-dishes at all bands for the equipment gains in Inset A. The Z factor correction is shown in Inset B to account for reflector gains at 6700 mc or for transmission line loss when tower-mounted, coax-fed dishes are used at 960 mc, 2000 mc, or 2600 mc. This db correction must be determined separately for each end of a link to account for varying tower heights and dish-and-reflector combinations; C/N ratio for the link is connected by the total $\pm$ Z factor.

How to Use the Graph

Example. A 20-mile link using 4-ft dishes is shown to provide a C/N of 42.6 db. If 200 ft towers exist at both stations, operation at 6700 mc with an 8 by 12-ft reflector requires a correction of +2 db per end, or a resultant C/N of 46.6 db. At 2000 mc, use of 1⅝-in. coax requires a correction of –3 db per end, or a resultant C/N of 36.6 db. The antenna system is seen to introduce a 10 db difference between the two bands.

Final corrections can be made for any specific equipment by comparing manufacturer's data with the typical gain in Insert B. Suppose the 2000 mc equipment had a transmitter power of 3 watts average, a receiver bandwidth of 7 mc, a noise figure of 12 db, duplexer loss of 1 db per end, and we allow 3 db for aging and safety factors.

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Available equipment gain is calculated as follows:

$T = 10 \log P_{avg} = 4.8$ dbw + 30 = 34.8 dbm

KTB = −114 dbm (at 1 mc) + 10 log 7 mc = −105.5 dbm

NF = 14 db (including 2 db duplexer loss)

R = KTB + NF = −91.5 dbm

T-R = 126.3 db less 3 db aging

The specific TR gain of 123.3 db is seen to be 3.3 db above the typical value of 120, so the above C/N for 2000 mc can be corrected to 39.9 db.

Link Performance

C/N as plotted is based on free-space transmission. Attenuation greater than α will be caused by path obstructions in the Fresnel zone or by fading. Db allowance for less than 0.6 R path clearance under normal or abnormal propagation conditions can be made by reference to the Planning Graphs in Part 1 and Part 5 of this series.

Fades directly increase the space loss (α or β) and correspondingly decreases C/N ratio at the receiver. In the preceeding 6700-mc example, the normal C/N of 46.6 db would drop to 16.6 db under propagation conditions corresponding to insertion of 30 db fade (or actual attenuator) in the transmission medium.

The target value of C/N used in planning a system depends upon the desired fade margin down to a specified minimum voice channel signal-to-noise quality.

Fade margin for a given per cent propagation reliability varies with location, season, and path characteristics.

Voice channel S/N is dependent upon the multiplex improvement down to a threshold range of low C/N values. This threshold of improvement is determined by the type of modulation and multiplexing system.

These factors will be covered in further articles in proper sequence. For now we simply suggest that you tentatively plan your RF link for a normal C/N ratio of 42 db, which will later prove a good target for typical paths in most pipe line communication systems.

* * *

Typical 2000-mc tower and antenna system showing top-mounted dishes and coax line attached to tower.

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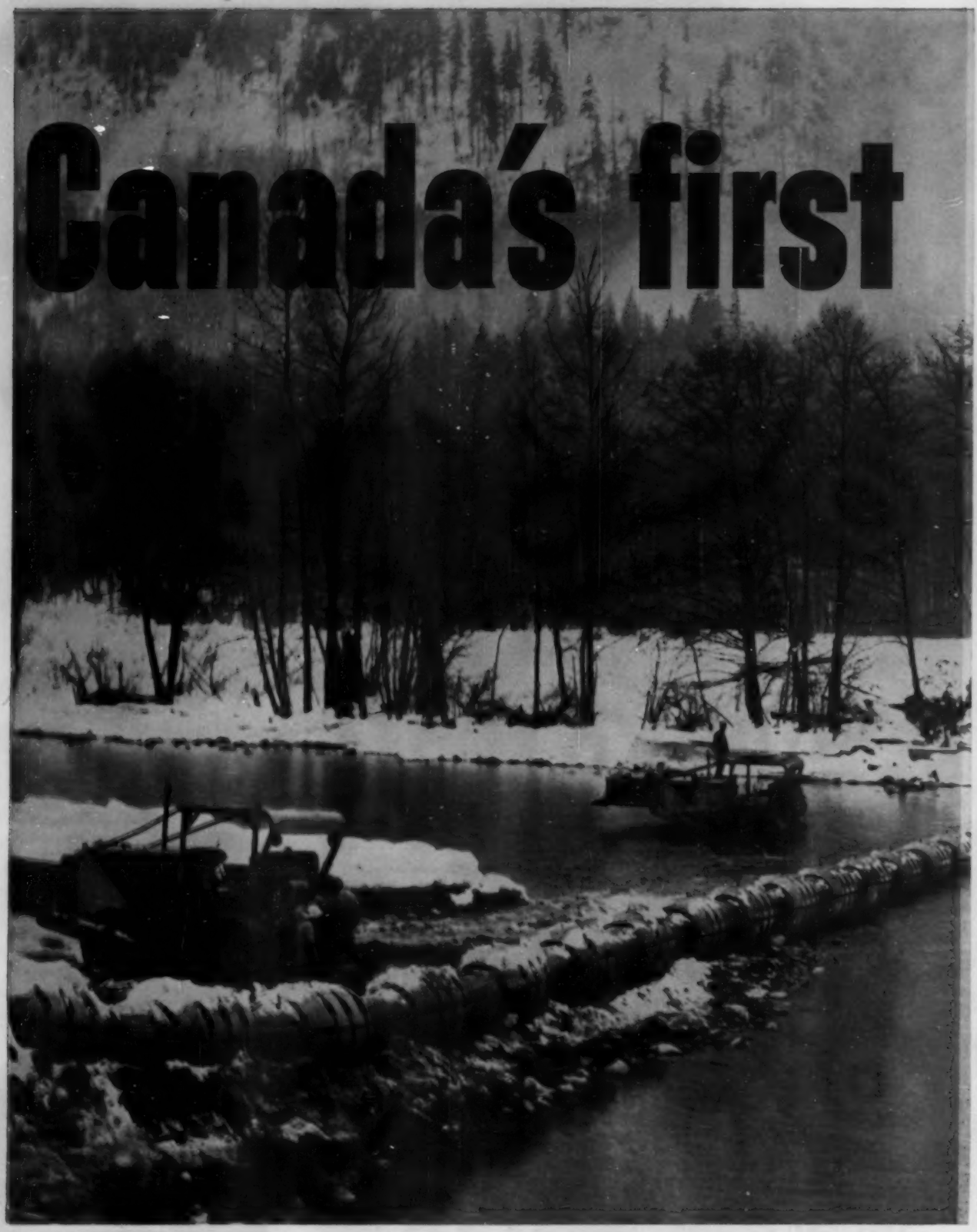

Photo shows the crossing of the Coquihalla River near Hope, British Columbia. The 30-inch diameter pipe is loaded with river weights and laid in a ditch beneath the river bed with eight feet of cover. Some of the river crossings, like this, were intentionally made during the winter when the water was at its lowest level.

"BIG INCH"

Kick-off for the line was at Huntington, B.C. Linkup with Pacific Northwest Pipelines is a short distance east of Vancouver. Westcoast has been authorized to draw gas from more than 42 million acres in the Peace River section in Alberta and British Columbia.

Westcoast Transmission Company, Limited, lays natural gas pipelines which will link British Columbia and New Mexico

TO tap the prolific gas resources of northeastern British Columbia and northwestern Alberta, Westcoast Transmission Company is now laying a 30-inch pipeline from the fields, almost due south to the international border near Vancouver. The line will provide natural gas for British Columbia and Pacific Coast States, the latter through a linkup with Pacific Northwest Pipeline Corporation which is currently completing a pipeline from New Mexico to the Northwest area.

Westcoast Transmission's 688-mile main line will have a maximum capacity of 660 million cubic feet per day and its completion will mark the first large-scale interchange of natural gas between western Canada's new and expanding fields and United States markets. Canadian Bechtel Limited are managers of engineering and construction for the project.

Marks first deliveries of 30-inch pipe from A. O. Smith Milwaukee plant

Approximately 22% of the 30-inch pipe used by Westcoast Transmission was shipped to the job from A. O. Smith's Milwaukee pipe mill. It was the first pipe of this size produced in the Milwaukee pipe mills' new facilities.

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Pipe Line Projects

Facilities Authorized For Chicago Area

The Federal Power Commission has granted certificates to Texas Illinois Natural Gas Pipeline Company, and Chicago District Pipeline Company, authorizing them to construct and operate natural gas facilities estimated to cost approximately $11,011,000.

Texas Illinois will construct a 30-in. loop line extending from Joliet for approximately 38 miles, adjacent to its existing 20-in. line, to connect with the existing 30-in. line of Chicago District, known as the Howard Street pipe line, in the Chicago area. Texas Illinois estimates the cost of this construction to be $6,411,000, which will be financed from funds on hand.

Chicago District proposes to construct approximately 14.1 miles of 36-in. from the eastern terminus of its Howard Street pipe line to the northerly city limits of Chicago, where it will make an additional connection with Peoples Gas Light and Coke Company and Northern Illinois Gas Company. Chicago District estimates the cost of constructing these facilities to be $4,600,000.

River Crossing Contracts Let by Trans-Canada

Contracts have been let by Trans-Canada Pipe Lines, Ltd., for two major crossings of the Assiniboine River on the prairie section of the natural gas transmission line, it was announced by Charles S. Coates, executive vice president and general manager.

Work on the two 1000-ft crossings will be started immediately by Marine Pipeline & Dredging Ltd., Vancouver, at points on the river near Miniota and Portage la Prairie, both in Manitoba.

Coates explained that this is the ideal time of year for river crossing work as water levels are low and construction is easier and more economical.

Two 34-in. diameter pipes, of heavy wall thickness, will be laid parallel for each crossing. This provides additional safety as well as reserve capacity for future load increases. The lines will be buried from 10 to 15 ft deep after being specially insulated and weighted with concrete. Trenches across the river bottom will be dug by "clamshells" working off barges, and by "draglines" working from the river banks.

Natural-Lone Star Hearing Postponed

The Federal Power Commission hearings, which were scheduled to begin October 1 in Washington, D. C., have been postponed to a date to be fixed by further notice in the reopened proceedings involving competing applications by Natural Gas Pipeline Company of America and Lone Star Gas Company, both proposing to build pipe line facilities to make additional natural gas available to Natural.

A commission presiding examiner filed a decision last February granting a certificate to Natural and denying Lone Star's application. The commission subsequently heard oral argument, and then on July 26 issued an order reopening the proceedings. In addition to the Natural and Lone Star proposals, the proceedings involve applications by three independent producers proposing to sell gas to Natural.

First Phase Texas Eastern's Program Approved

Texas Eastern Transmission Corporation has received Federal Power Commission authorization for an $82,700,000 expansion project involving the importation of substantial quantities of natural gas from Mexico, according to Orville S. Carpenter, president. The commission also set October 29 as the date for hearings to begin on the second phase of Texas Eastern's expansion and diversification program, which relates to reconversion of a major segment of the Little Big Inch line to petroleum products service. Including the second phase, which will cost about $64,000,000, this program will involve about $147,000,000.

Completion of the first phase of the program will increase capacity of the company's system by approximately 250,000,000 cu ft a day.

Carpenter said that Mexican gas will be available at the rate of 115,000,000 cu ft a day initially with the contract providing for this volume to be increased up to 200,000,000 cu ft a day as additional reserves in the fields covered by the contract are developed. Additional supplies of gas have been purchased along the route of a new 30-in. line that will extend from Beaumont to McAllen, Texas, on the Rio Grande and connect Texas Eastern's 5700 mile pipe line network with a line being built by Mexican authorities to the international border.

Construction will begin immediately, Carpenter said, on the facilities just authorized. These include approximately 422 miles of 30-in. from McAllen, Texas, to Texas Eastern's Vidor, Texas, compressor station; approximately 45 miles of 24-in. pipe connecting Texas Eastern's existing line near Provident City, Texas, to the new line; loops totaling about 77 miles at various locations along the existing 30-in. system; approximately 147 miles of supply and sales laterals; new and additional compression facilities totaling 32,250 hp, and approximately 20 sales measuring and regulating stations. The project should be completed by the fall of 1957.

At the same time the FPC granted authorization to Texas Eastern Penn-Jersey Transmission Corporation, a wholly-owned subsidiary of Texas Eastern, for the construction and lease to the parent company of new and additional compression facilities totaling approximately 33,300 hp.

PG&E to Add Horsepower At Three Compressor Stations

Pacific Gas and Electric Company has awarded contracts to Fluor Maintenance, Inc., Martinez, California, subsidiary of The Fluor Corporation, Ltd., Los Angeles, for construction of additional compressor station facilities at Kettleman Hills, Hinkley, and Needles, California.

The work is scheduled for completion late this year, at a cost in excess of $500,000.

Rangeland Asks Permit For 450-Mile Oil Line

A new 450-mile crude pipe line from the Sylvan Lake area to Sundre, in Central Alberta, is proposed by Rangeland Pipe Line Company, subsidiary of Hudson's Bay Oil and Gas Company. Permission must be obtained from the Alberta Conservation Board.

A similar application by Rangeland was denied by the board earlier this year when a permit was granted to Cremona Pipe Lines, a subsidiary of Home Oil Company, Ltd., to build a pipe line from Sundre to Calgary. The new Rangeland application seeks the right to transport oil surplus to Cremona's requirements.

The pipe line proposed by the new application would tie in with an existing Rangeland line that joins a Texas Company line extending north to Edmonton.

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Salt Lake-Spokane Products Line Considered by Majors

Four major companies are considering the construction of a products pipe line from Salt Lake City, Utah, to Spokane, Washington, according to John E. Swearingen, Chicago, executive vice president of Standard Oil Company (Indiana). The companies involved are Service Pipe Line Company (affiliate of Indiana Standard), Continental Pipe Line Company, Sinclair Pipe Line Company, and Phillips Petroleum Company.

The project is still in the discussion stage, according to Swearingen, who said that a favorable decision would depend on rates and volume.

Texas Gas Files For Louisiana Construction

An application by Texas Gas Transmission Corporation for the construction and operation of natural gas facilities in Louisiana has been accepted for filing by the Federal Power Commission.

Involved are 13 miles of 20-in. line from the end of the company's East Lake Palourde 20-in. line in Assumption Parish to the Thibodaux area, Lafourche Parish, together with a gas purchase meter station in Thibodaux area.

Two Major Companies Consider 600-Mile Line

Shell Oil Company and Standard Oil Company of California are studying plans to build a 600-mile pipe line to the Los Angeles area from the newly-discovered oil reserves in the Four Corners area, where the boundaries of Utah, Arizona, New Mexico, and Colorado intersect.

The announcement was made jointly in San Francisco by H. S. M. Burns, president of Shell, and T. S. Petersen, president of Standard.

They said such a line would follow generally uninhabited desert country on a route running southwestward from Four Corners, north of Flagstaff, Arizona, just north of Kingman, Arizona, and through the Mojave Desert.

While engineering plans are still in the tentative stage, in conjunction with a survey of reserve potentials in this area, the two officials indicated consideration is being given to a 14-in. line with initial capacity of about 50,000 bbl a day and an ultimate capacity of approximately 100,000 bbl through addition of more pumping stations.

Construction would take from 20 to 24 months and would include a far-flung system of gathering lines in the Four Corners region.

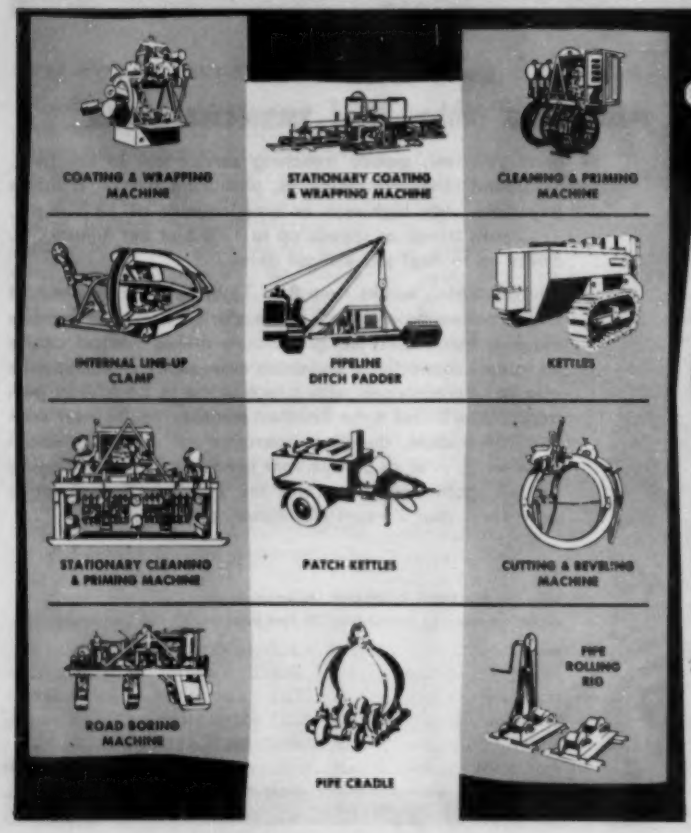
Service Asks Bids On Connecting Lines

Bids have been requested from contractors to lay pipe lines connecting 16 new leases to the Service Pipe Line Company system in North Dakota, R. R. Strand, manager of the company's Wyoming division announces.

Strand, with headquarters at Casper, said about 20.9 miles of 3, 4, and 6-in. pipe will be laid to connect leases in the Antelope, Charlson, Sanish, and Blue Buttes pools in McKenzie County. The lines will connect with the company's gathering system in this area, and then lead into the trunk system. The 157-mile trunk system connects the Tioga and Beaver Lodge fields to the north with a refinery at Mandan.

PG&E Announces Plans For 200-Mile Gas Line

Pacific Gas and Electric Company has disclosed plans for a 200-mile natural gas line to be constructed next year at a cost of about $9,500,000. A 12-in. line is proposed, with capacity of 20,000,000 cu ft a day. It will take gas from the Beehive Bend, Perkins Lake, and Corning fields in Glenn and Tehama counties, extend northward to Red Bluff, thence westward across the valley and rugged mountains to Fortuna, Eureka, and Arcata on the California coast.



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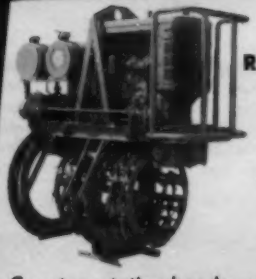

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American Louisiana Hearing Postponed

Federal Power Commission hearings previously scheduled to begin October 9 in Washington, D. C., involving applications by American Louisiana Pipe Line Company, of Detroit, Michigan, for the construction of pipe line facilities in the Midwest, and Gulf Refining Company, which seeks authorization for the sale of natural gas to American Louisiana, have been postponed to a date to be fixed by future notice.

American Louisiana is seeking authorization for the construction and operation of 35.8 miles of 8⅝-in. gathering line, four new compressor stations with an aggregate of 42,000 hp, the addition of 2000 hp to two existing stations, and metering and regulating stations.

Manufacturers Authorized To Operate Facilities

The Manufacturers Light and Heat Company, of Pittsburgh, Pennsylvania, has been authorized by FPC to operate existing, leased and proposed facilities for the transmission of natural gas in Pennsylvania.

The FPC order also dismissed the application of Trans-Penn Transit Corporation, of Bradford, Pennsylvania, seeking authorization for the operation of about 109 miles of pipe line in McKean and Clinton counties, Pennsylvania, and a compressor station at Emporium, Pennsylvania, which it leases from the Trustees of The Sixty Trust. These facilities will now be leased to Manufacturers.

Manufacturers was authorized to continue operation of its Clinton County line and its existing 2640 hp Renovo compressor station. Manufacturers also will construct a new compressor station near Jeanette, Pennsylvania, with a 1760 hp rating; and various taps, and measuring and regulating stations.

Hearings Postponed On Five Applications

A Federal Power Commission hearing on the applications of five companies for natural gas projects in the Midwest previously scheduled to open October 2 in Washington, D. C., has been postponed until further notice.

In the meantime, new related applications and amendments to the initial findings have been made by all but one of the five companies.

The original applications were filed by Natural Gas Pipeline Company of America, Texas Illinois Natural Gas Pipeline Company, Chicago District Pipeline Company; Pacific Northwest Pipeline Corporation, and Colorado Interstate Gas Company. The original applications proposed the construction of 1329 miles of pipe line, 116,300 compressor hp, supercharging of 86 engines. The revised applications of these companies call for construction of 1224 miles of pipe line, 101,985 net compressor increase of hp, supercharging 86 engines.

Two Spreads Added On Trans-Canada Work

Two more construction spreads have begun work on the Alberta to Winnipeg section of Trans-Canada Pipe Lines' natural gas transmission system, it was announced by Charles S. Coates, executive vice president and general manager of the company.

This brings to four the number of spreads now at work on the 574-mile stretch of 34-in. pipe. The two new starts are by Mannix, Ltd., and Dutton-Williams Brothers, Ltd., both of Calgary. Mannix established construction headquarters in Regina and will work on the stretch of the line between Moose Jaw and a point near Wolseley, Saskatchewan. Dutton-Williams has set up a field base at Grenfell, Saskatchewan, and will work from the Wolseley area to a point near Miniota, Manitoba. The two sections cover about 190 miles.

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● **Dutton-Williams Brothers, Ltd., Pacific Building, Calgary, Alberta.** Has 120 miles of 30-in. gas line for *Westcoast Transmission Company, Ltd.*, between Taylor and Azouzetta Lake, British Columbia. Has 136 miles of 10-in. natural gas line between Lake Wabamum and Hinton, Alberta, for *North Canadian Oils, Ltd.* Has 45 miles of 10-in. line for *South Alberta Pipe Lines* between Etzikom and Medicine Hat, Alberta. Has a 30-in. crossing on the Pine River for *Westcoast Transmission Company*. Also has 65 miles of 8-in. line for *Cremona Pipe Lines* between Sundre and Calgary, Alberta. Has undetermined amount of 12 and 8-in. gathering line to lay for *Canadian Gulf Oil Company*, at Pincher Creek, Alberta. Also has 46 miles of 12 and 6-in. in the Rimbey-Joffre field, Alberta, for *Rangeland Pipe Line*.

● **O. R. Burden Construction Corporation, 6702 East Twenty-first Street, Tulsa, Oklahoma.** Has 90 miles of 8-in. line to take up and recondition for the *Ohio Oil Company* between Teutopolis and Martinsville, Illinois.

● **R. H. Fulton & Company, Inc., P. O. Box 1526, Lubbock, Texas.** Has 252 miles of 22-in. line for *Colorado Interstate Gas Company* between Rock Springs and Laramie, Wyoming.

● **Somerville Construction Company, Ada, Michigan.** Has 67 miles of 10 and 12-in. line from Clare County to Traverse City, Michigan, for *Michigan Consolidated Gas Company*. Also has 60 miles of 10 and 12-in. line between Muskegon and Ludington, Michigan, for the same company.

● **H. C. Price Company, Box 1111, Bartlesville, Oklahoma.** Has 246 miles of 30-in. natural gas line from Hancock County, Indiana, to Slaughters, Kentucky, as part of a joint venture with Houston Contracting Company on 783 miles of 30-in. for *American-Louisiana Pipe Line Company* from Willow Run, Michigan, to the Arkansas state line near Eudora, Arkansas. Also has 82 miles of 26-in. line for *Tennessee Gas Transmission Company* near Chauncey, Ohio.

● **Sheehan Pipe Line Construction Company, 514 National Bank of Tulsa Bldg., Tulsa, Oklahoma.** Has 90 miles of 14-in. to lay, 75 miles of 8-in. take-up for *Sun Pipe Line Company* between Marcus Hook, Pennsylvania, and Plainfield, New Jersey.

● **Missouri Valley Dredging Company, 222 William Street, Omaha, Nebraska.** Has three major crossings on *Sun Pipe Line Company's* 109-mile new products line between Twin Oaks, Pennsylvania, and Newark, New Jersey; the crossings are on the Schuylkill, Delaware and Raritan rivers.

● **Mannix, Ltd., 332 7th Avenue W., Calgary, Alberta.** Has 110 miles of 30-in. gas line at the south end of *Westcoast Transmission Company's* gas line from Peace River area, Alberta, to U. S.-Canadian border near Vancouver, British Columbia. Has 90 miles of 34-in. gas line for *Trans-Canada Lines, Ltd.*, between Moose Jaw and Wolseley, Saskatchewan.

● **Oklahoma Pipe Line Contractors, 6612 Hines Blvd., Dallas 20, Texas.** Has 327 miles of 18-in. line for *Plantation Pipe Line Company* between Baton Rouge, Louisiana, and Helena, Alabama. Has 74 miles of 6-in. for *Tennessee Gas Transmission Company* between the Brazos River near West Columbia, Texas, and Lavaca Bay.

● **Hallmac Construction Company, 3701 Buffalo Drive, Houston 19, Texas.** Has 400 miles of 24 to ¾-in. line for Spokane *Fuel and Gas Company* for natural gas distribution system within the city of Spokane, Washington.

● **Latex Construction Company of Georgia, P. O. Box 184, Fond du Lac, Wisconsin.** Has 90 miles of 16 and 20-in. line between Oshkosh and Milwaukee, Wisconsin for *Michigan-Wisconsin Pipe Line Company*.

● **Majestic Contractors Limited, 408 Royal Trust Building, Edmonton, Alberta.** Has contract for 50 mile gathering system at Redwater, Alberta. Has 40 mile gathering system to lay for *Westspur Pipeline* in the Estavan, Saskatchewan, area. Has 39 miles of 12-in. for *Imperial Oil Limited* between Waterdown and North Toronto, Ontario. Also has 106 miles of 34-in line for *Trans-Canada Pipe Lines, Ltd.*, between Burstall and Stewart Valley, Saskatchewan. Has undetermined amount of city distribution system for *Consumer Gas Company* in Toronto.

● **Collins Construction Company, Box 86, Port Lavaca, Texas.** Has contract with *U. S. Government Agencies in Europe* to lay 8000 ft of 24-in. sea-loading line in Bay of Biscay.

● **Panama-Williams Corporation, 1418 Melrose Building, Houston, Texas.** Has 76 miles of 4 and 6-in. line for *Phillips Chemical Company* between Pasadena and Sweeny, Texas.

● **Holdren Construction Company, P. O. Box 417, Mount Vernon, Illinois.** Has 12 miles of 4-in. line to lay for *Town Gas Company of Illinois* extending from the Panhandle-Eastern line below Auburn to Girard, Illinois. Also has 42 miles of small distribution lines to lay for the same company in the cities of Virden, Girard, and Thayer, Illinois.

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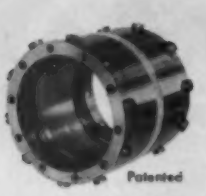

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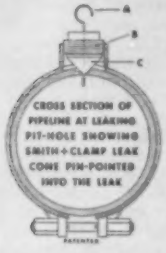

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● **Houston Contracting Company, 2707 Ferndale Place, Houston 6, Texas.** Has as joint venture with H. C. Price Company contract for 121 miles of 22-in. natural gas line for *American Louisiana Pipe Line Company* from near Defiance, Ohio, west to the vicinity of Bridgeman, Michigan. Has 120 miles of 20-in. and 11 miles of 16-in. natural gas line to lay for *Texas Gas Transmission Corporation* from the vicinity of Eunice, Louisiana, east to the vicinity of Thibodaux, Louisiana. Also has 30 miles of 8 and 12-in. natural gas lateral lines for *Tennessee Gas Transmission Company* in the vicinity of Golden Meadow and Leeville, Louisiana.

● **Ross-Powers Construction Company, Box 2038, Billings, Montana.** Has 40 miles of 12-in. line for *Montana-Dakota Utilities Company* between Baker and Glendive, Montana. Also has 10 miles of 6-in. to lay eastward from Cabin Creek, Montana, for the same company.

● **M. G. M. Construction Company, P. O. Box 1056, Concord, California.** Has 25 miles of 6-in. for *Pacific Gas & Electric Company* from San Ardo gas fields to King City, California.

● **Western Construction Company, P. O. Box 798, Austin 64, Texas.** Has 12 miles of 30-in. for *Transcontinental Gas Pipe Line Corporation* between Scottsville and Charlottesville, Virginia. Also has contract for a 30-in. Susquehanna River crossing for the same company.

● **Engineering-Construction Company, 407 First National Building, Tulsa, Oklahoma.** Has undetermined amount of 1¼ through 8-in. city distribution lines in the town of Brookings, South Dakota, for *Northwest Public Service Company.*

● **Fulton Banister Ltd., 625 Northern Hardware Building, Edmonton, Alberta.** Has 18 miles of 6-in. line to lay for *Mid-Western Gas Ltd.* between Redwater and Fort Saskatchewan, Alberta.

Hope To Add Station At Fink Storage Field

The Federal Power Commission has granted a certificate to Hope Natural Gas Company, Clarksburg, West Virginia, authorizing it to construct and operate a 5400-hp compressor station in the Fink storage field in West Virginia. The cost is estimated at $2,138,761.

Hope stated that the proposed facilities will enable it to cycle an additional 10,000,000,000 cu ft of gas annually. With storage inventories of 35,000,000,000 cu ft, the proposed facilities enable the company to deliver safely an additional 110,000,000 cu ft per day from the storage area. The proposed additional facilities will enable the company to increase its deliveries to 160,000,000 cu ft daily while maintaining a storage inventory of 26,000,000,000 cu ft.

The FPC on June 20 granted Hope temporary authorization for the construction and operation of the compressor station.

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PIPE LINE PERSONALS

▸ **George A. McDonald,** has resigned as press relations manager of the American Gas Association. He has been associated with AGA for 11 years.

▸ **J. E. Condon** has been named manager of purchasing-stores for Shell Pipe Line Corporation, Houston, Texas. He was formerly manager of purchasing-stores for Shell Development Company, Emeryville, California.

R. H. Chase, senior head office representative in purchasing-stores, will replace Condon in Emeryville.

▸ **D. O. Davis** has been promoted to chief operator at Tompkinsville, Kentucky, by Texas Eastern Transmission Corporation. Other advancements are: **E. E. Blankenship** to chief operator at Mt. Pleasant, Tennessee; **M. L. Belknap** to foreman at North Little Rock, Arkansas, and **L. H. McClure** to chief operator at Egypt, Mississippi.

▸ **Verle A. Smith,** Kerr-McGee Oil Industries; **James I. Banes,** Bethlehem Supply Company; **Harold B. Putnam,** Charles Wheatley Company, and **Gus Baker,** Frank Wheatley Supply Company, have been admitted to membership in The Pipe Liners Club of Tulsa, Oklahoma.

George T. Naff

O S. Carpenter

▸ **George T. Naff,** president of Texas Eastern Transmission Corporation, has been elected vice chairman of the board and **Orville S. Carpenter,** vice president and comptroller, president and a member of the board of directors. **George R. Brown,** chairman of the board, stated that creation of the executive position of vice chairman of the board was intended to strengthen the top management organization of the company and place greater emphasis on long range plans. As vice chairman, Naff will have general supervision of the affairs of the company with particular emphasis on growth and diversification as well as the extensive financing program that Texas Eastern will undertake in the near future.

Carpenter, as president, will exercise primary executive authority in the operations of the company.

▸ **S. P. Osborn** has been elected comptroller of Texas Eastern Transmission Corporation. Assistant comptroller since 1955, he will fill the position made vacant when **Orville S. Carpenter** was elected president of the company.

▸ **Calvin Butler** of Homer, Ohio, retired October 1 as operating engineer at the Ohio Fuel Gas Company's treat compressor station. Butler has been with Ohio Fuel and its parent organization, the Columbia Gas System, for 41 years.

▸ **R. S. Cannon,** chief electrical engineer, Plantation Pipe Line Company, has been named chairman of the committee on Petroleum Industry of the American Institute of Electrical Engineers, it has been announced by **N. S. Hibshman,** secretary of the Institute. **L. E. Oberhelman,** head engineer of the Standard Oil Company of Indiana, Sugar Creek, Missouri, has been named vice chairman, and **T. V. Bockman,** of Corpus Christi, Texas, secretary.

Because of the increasing importance of electrical engineering in the petroleum field, committee status was assigned to the petroleum unit, which was a sub-committee until August, 1954.

▸ **F. C. Walters,** after a six months' leave of absence, has returned to work in Panhandle Eastern Pipe Line Company's transmission department. He will assist **F. J. McElhatton,** superintendent of transmission.

Richard L. Ryan has been promoted by the company from assistant superintendent of District No. 14, Maumee, Ohio, to superintendent of the district. He succeeds **Garlin F. Crouch,** transferred to the central division as superintendent. **Guy M. McElfresh,** assistant superintendent of District No. 31, Delavan, Illinois, becomes assistant superintendent at Maumee. **Everett W. Tice,** clerk at District No. 3, Iuka, Kansas, has been made assistant district superintendent at Delavan.

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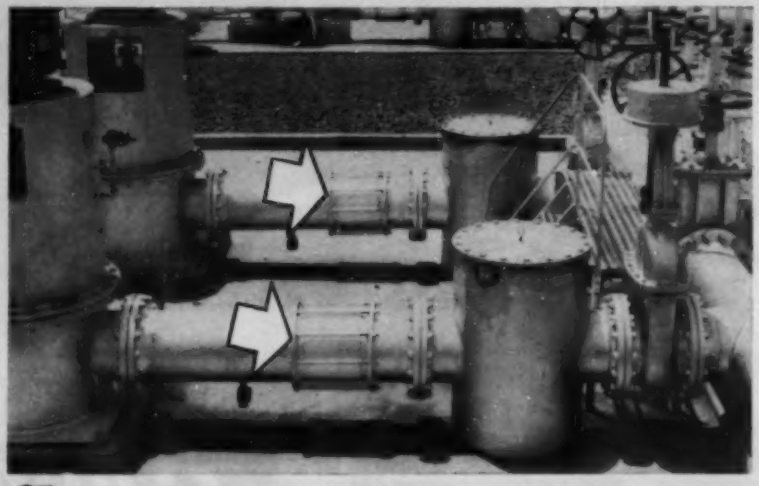
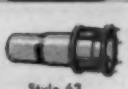


Style 38 Coupling

Style 40 Long Sleeve

Hydropolis® Asbestos Cement Pipe Clamp



Style 63 Expansion Joint

Style 39 Insulating Coupling

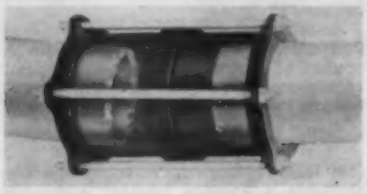
NEW Pipe Line Equipment

• machinery • supplies • services

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

(81) Pipe Patch. Smith-Blair has announced an improved coupling for repairing misalignment breaks in water, gas, or oil pipe lines.

Called the Series 4K Flexible Cut-In Coupling, it is applicable to cast iron, as-



bestos-cement, or steel pipe and is installed with the pipe in place. This cut-in coupling acts as a double coupling replacing twice the length of pipe cut out.

The pipe is repaired quickly, as well as given additional flexibility. Pipe can be out of alignment over 6 deg and be repair-connected in place.

Smith-Blair.

(82) Piston Pressure Switch. A Barksdale pressure switch, 9622 or C9622, is said to be capable of sensing two different pressures in one system and actuating independent electrical circuits at any two desired points.

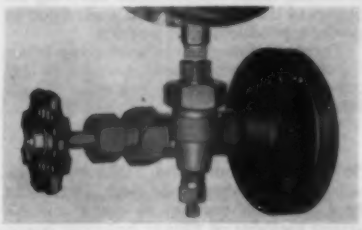
Switch may be used to maintain a pressure where it is imperative that the system pressure does not exceed or fall below predetermined values. It is claimed to accurately sense any system over an adjustable range of 15 to 3000 psi for proof pressure from 3000 to 7000 psi, depending on the switch setting.

Pressure settings are made by two external adjustment screws that can be locked in place to avoid accidental disturbance.

Barksdale Valves.

(83) Valve for Instrument Piping and General Use. A valve for instrument piping and general use which acts as a block valve, as well as greatly reducing the number of threaded connections required, is being introduced by Jerguson Gage & Valve Company.

Valve, the Jerguson No. 66U-VG, is an offset valve with a vertical rising ball check on the downstream side of the seat and with a solid shank connection to the vessel, which makes it acceptable as a



block or root valve and makes it possible to eliminate the usual block valve.

These valves combine unions, nipples, reducers, elbows, tees, valve and drain valve into one space-saving unit.

Jerguson Gage & Valve Company.

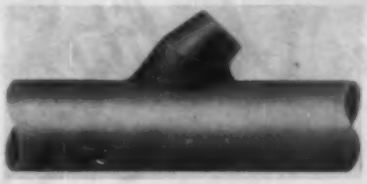
(84) Voltage Welders. Harnischfeger's welding division has announced a line of modified constant-voltage welders that permit better control over a wide range of applications.

The line consists of 300, 500, 750, and 1200-amp machines.

Main feature of the P&H modified constant-voltage machines is an adjustable slope control that gives a softer arc, eliminates burn-back and stubbing, and provides a stable, spray-type deposit when properly adjusted for aluminum, stainless steel, and other alloys.

Harnischfeger Corporation.

(85) Angular Branch Connections. Bonney Forge has announced a branch welding pipe fitting for constructing angular



branch connections with a full penetration weld.

Bonney "Elbolets" are used for making 45 deg connections for directional flow and instrument connections, and for connections into elbows for instruments, drips, and hangar and support connections.

Bonney Forge.

(86) Rotary Solenoid Valve. Pneu-Hydro-Valve has developed a rotary solenoid valve especially for high-pressure aircraft hydraulic, pneumatic and fuel systems over a pressure range of 0 to 3000 psi.

This valve was designed to handle most all fluids, including liquid oxygen and nitrogen with complete reliability. The small, light-weight valve features straight-through flow and is available with ports for ¼, ⅜ or ½-in. diameter tubing.

Pneu-Hydro Valve Corporation.

(87) Auto Fuel Injection System. An electronic fuel-injection system that is claimed will replace a conventional carburetor on passenger cars, leading to increased power, quicker starting and warm-up periods, plus faster throttle response, has been introduced by Bendix Aviation.

The timed, self-priming system, which provides a wider latitude in fuel characteristics for high-compression engines, is called the "Electro-jector." It is now ready to be adapted to engines of any car manufacturer and is said to be the first system to be developed that does not require a special drive off the engine.

Bendix officials point out that the simplified design of the Electro-jector means increased power for safety, better fuel economy, quicker starts and warm-up, wider selection of fuels — another economy for the average motorist — more room under the hood, faster and livelier response to the throttle, elimination of vapor locks, and no cornering, or hill-angle effects.

Bendix Aviation Corporation.

(88) Automatic Welding Equipment. A line of "Sureweld" semi-automatic and fully automatic welding equipment, said to provide maximum versatility and economy in CO_2 and inert-gas metal-arc welding, has been announced by National Cylinder Gas.

Equipment is designed for single-pass horizontal and flat-position welding, using a constant-voltage type d-c power source. It consists of a welding control and electrode drive unit, a welding gun or automatic welding torch, and interconnecting gas and water cable assemblies.

National Cylinder Gas Company.

(89) Bulldozer Blade. A 104-in.-wide bulldozer blade attachment for the No. 977 Traxcavator has been announced by Caterpillar.

The straight blade is useful for leveling, clean up, and backfilling operations usually accomplished with the Traxcavator bucket. Its greater width is said to make it more efficient than the bucket for these jobs.

Caterpillar Tractor Company.

(90) Self-Propelled Pipe-Cleaning Machine. A self-propelled, rotating head pipe cleaning machine designed for use by maintenance crews working on loaded lines has been introduced by Remco Manufacturing.

Machine enables two men to clean up to nine times more pipe in one day than can be handled by hand cleaning. It is said to completely eliminate the need for air compressors or electric generators.

Requiring only 6-in. of clearance under the line, the complete unit consists of a revolving head and a separate power plant, which is easily mounted on the revolving head. Revolving head is adjustable to any required travel speed and uses standard cutters, knives, or brushes.

Remco Model C/M Pipe Cleaning Machines are available in four models with each model capable of cleaning three successive sizes of pipe. Pipe sizes that can be handled by the machine range from 4 in. through 26 in.

Remco Manufacturing Company.

Remco Pipe Cleaning Machine.

NEW Literature

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

(91) Building and Accessory Line. A colorful catalog detailing Stran-Steel's newly enlarged line of industrial and commercial buildings and accessories has been published by the corporation. Prominently featured in the large, illustrated brochure are Stran-Steel's completely new series of rigid frame structures, two 50 and 60-ft bow-string truss buildings and the recently developed Stran-Satin metal wall.

Stran-Steel Corporation, a unit of National Steel Corporation.

(92) How to Tape Pipe. Techniques for protecting underground pipe from corrosion with "Scotchrap" brand pipe insulation tape is the subject of a how-to-do-it booklet announced by Minnesota Mining and Manufacturing.

Called "Tape It Easy," this 24-page booklet provides step-by-step photographs and instructions for wrapping bends, elbows and short sections, patching pipe with tape, preparing joint surfaces for wrapping, wrapping welded joints, and taping straight pipe sections as well as street "T" fixtures, and other typical fittings.

An additional section contains a "summary of helpful suggestions" for making pipe protection with tape easy.

Minnesota Mining and Manufacturing Company.

(93) Pipe Insulation. Union Asbestos & Rubber has published a 40-page catalog on Unibestos Pipe Insulation.

Designed as a convenient reference guide, the new catalog presents an entirely new way to specify proper thickness for pipe insulation. The new method is based on the "J" factor.

Booklet also features detailed drawings that show how single-layer Unibestos is applied to various vertical and horizontal expansion joints as well as to pipe bends, flanges, valves, and fittings.

Union Asbestos & Rubber Company.

(94) Rust Preventives. Valvoline now has available a 16-page booklet explaining how to solve the problems of rust with Valvoline Tectyl Rust Preventives and Rust Removers. Chapters are devoted to: The Problem of Rust, Cleaning the Product, Materials in Corrosion Preventives, and How to Choose a Rust Preventive.

Valvoline Oil Company.

(95) Mechanical Packing. Belmont Packing & Rubber has issued a 24-page condensed catalog on mechanical packings, which contains 246 types for every service in industry.

Featured are several recent packing developments, including the multi-purpose Bel-Vee V-Ring Packings, the Criss-Cross Braid Packing Series, Twisted Foil Packings for oil and distillate temperatures to 1000 F, and an Inconel-wire reinforced plastic packing for valves handling superheated steam at temperatures up to 800 F.

The Belmont Packing & Rubber Company.

(96) ASA Members. The 115 national technical societies, trade associations and public interest groups, and the 2300 companies which are affiliated with the American Standards Association are listed in a 63-page booklet issued by ASA.

It also names the officers and the board of directors of the association. Gives state and city governments, colleges and universities and various individuals affiliated with ASA.

American Standards Association.

(97) Safe Use in Plants of Flammable Liquids. A practical, non-technical, illustrated explanation of the nature and safe plant use of flammable liquids is now available from Protectoseal, covering all phases of their handling and application in modern production procedures.

Three sections of this continuing series have now been published in a loose-leaf cover binder with ample space for the remaining sections.

The Protectoseal Company.

(98) Lapping Compound. Timesaver Products has published a 24-page, illustrated booklet which outlines in detail money-saving methods of fittings bearings, gears, slides, pistons, etc., with Timesaver Lapping Compound.

Timesaver Lapping Compound is claimed not to charge or imbed into metal surfaces or continue to cut.

Timesaver Products Company.

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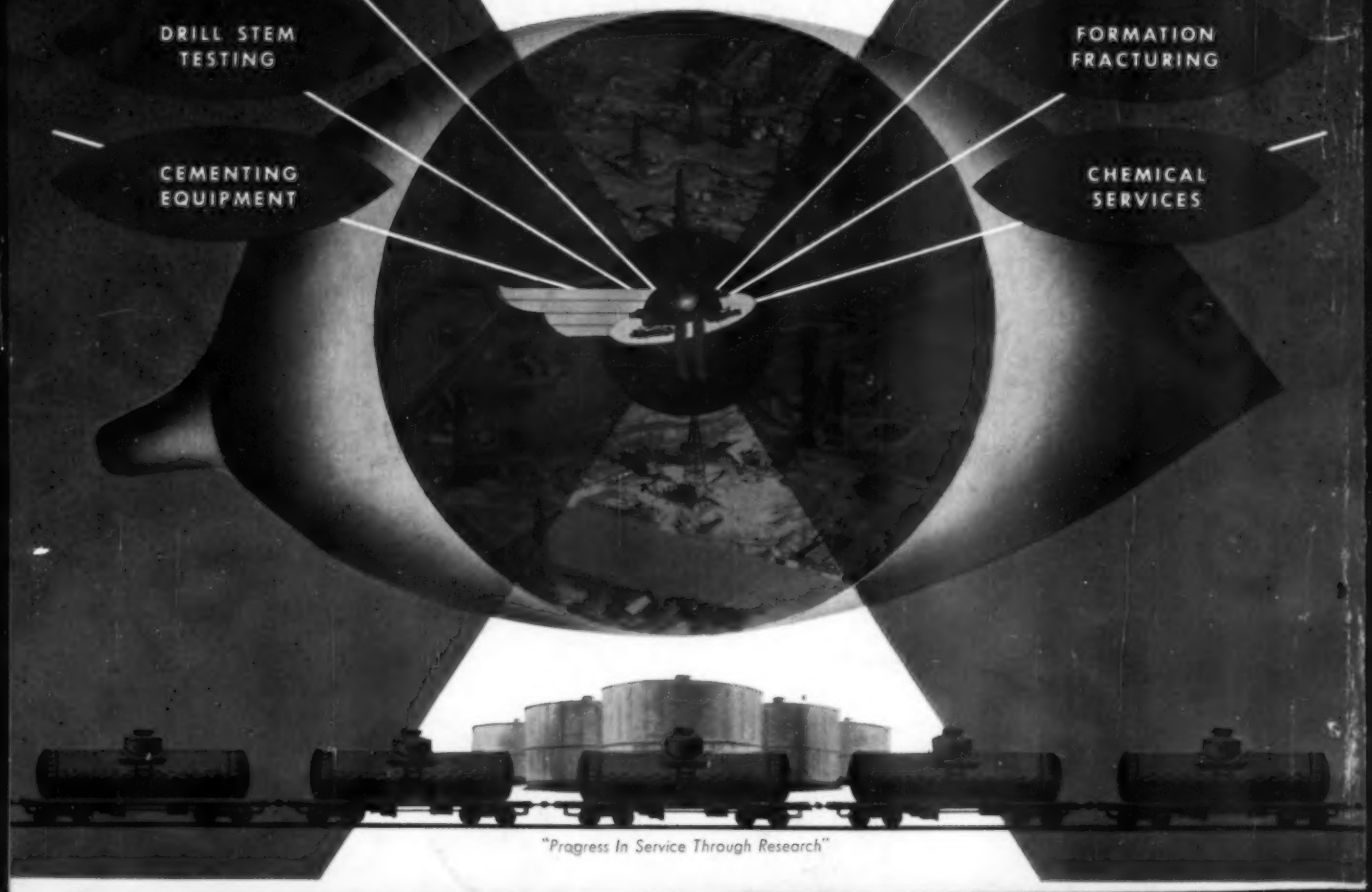

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